# FIND A FALLING STAR

## HARVEY H. NININGER

*Introduction by* DR. FRED L. WHIPPLE
*Phillips Professor of Astronomy*
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FIND

Also by HARVEY H. NININGER

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**DR. FRED L. WHIPPLE**

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*lo the hundreds of school officials who, seeing the educational value of our program, gave encouragement to the new science of meteoritics.*

*To the farmers, ranchmen, and others who live close to the land and were willing to broaden the quest beyond measure.*

*To my long-suffering family for the support of their love, for their loyalty and their enthusiasm for the search that continues.*

*To my friends—hundreds of them—who have shared the talking and the seeking; and to a particular friend, Herbert G. Fales, who would not allow me to abandon this book.*

*And last but not least, to Mr. George Boyd, Coordinator of Research at Arizona State University, who grasped the full significance of our program and would not rest until he saw the fruits of our labors safely installed in that university.*

# PREFACE

Everyone agrees that it is important that man understand something of the history of the earth and of the universe, particularly the Solar System. This book, and indeed the author's whole life, reflects in a small and modest way an attempt to help with that understanding.

It seems high time that man cease propagating the myth that the earth was created one afternoon about 6,000 years ago and that he gear his thinking to a recognition of the fact that he lives in the midst of a process the individual incidents of which are so widely separated in time and space that no one ever sees enough of it to adequately describe it; but by careful evaluation of recorded incidents he may build a reliable concept of Nature, including himself, and his race, basking in the radiance of increasing knowledge and of the ingenuity behind the whole performance.

It is in this spirit that the investigations of the author and his wife, Addie, have been carried on for more than a half-century.

Although we were not able to get the necessary financial support from educational or research institutions for more than the equivalent of a few months of field work during our thirty most active years, I cannot refrain from expressing our gratitude for the moral support that came from many quarters. Letters and invitations to lecture in hundreds of colleges, universities, high schools, museums, etc. all provided an outlet for our message. Writers, who found in our program an exciting and rewarding prospect for the farming population, ranchers, hunters, fishermen and nature lovers. Hundreds of lucky finds kept the program alive.

Scientists who were especially helpful by way of encouragement were: Dr. Oliver C. Farrington, Head, Department of Geology, Field Museum; J. D. Figgins, Director, Colorado Museum of Natural History; Dr. Clyde Fisher, Curator of Meteorites, American Museum of Natural History; Prof. Curvin H. Gingrich, Professor of Astronomy, Carleton College; Dr. Frederick C. Leonard, Professor of Astronomy, UCLA; Dr. Forest R. Moulton, Permanent Secretary, A.A.A.S.; Prof. F. K. G. Mullerreid, University of Mexico; Prof. Harlow Shapley, Department of Astronomy, Harvard Univ.; Edward Steidle, Director, Penn. State College; Dr. Fletcher Watson, author of *Between the Planets,* Harvard Univ.; Dr. Fred L. Whipple, Department of Astronomy, Harvard Univ.; Dr. Alexander Wetmore, Director, U. S. National Museum; Prof. E.J. Workman, Director, New Mexico School of Mines; and many others.

Writers who kept our activities before the reading public were: Neil M. Clark, *Saturday Evening Post;* F. C. Cross, magazine writer; Roscoe Fleming, magazine writer; Gene Lindberg, science writer, Denver *Post;* Alexis McKinney, City Editor, Denver *Post;* Ernie Pyle, roving reporter; Alan Swallow, Publisher; and a host of newspaper editors. The jacket photo of the author by Orin Sealey of the Denver *Post* is used with grateful thanks.

Participants in field work were: H. G. Fales, Dean Gillespie, John Hilton, Irving Hoglin, Alfred Knight, Robert Nininger, Alex Richards, Jim Rothrock, Don Thompson, O. J. Walters, and the U.S. National Museum.

President D. W. Kurtz of McPherson College was a constant source of encouragement.

Very special credit goes to our daughter, Mrs. Doris Banks, for her weeks and months of editing the original manuscript.

H. H. Nininger

Sedona, Arizona
July, 1972

# INTRODUCTION

*H. H. Nininger* and *Meteorites go* together, like word pairs such as *bread* and *butter,* at least for those who study these rare samples of cosmic debris. Meteorites *were,* indeed, bread and butter for the Nininger family, the first ever to survive by finding, collecting, trading, selling, and exhibiting meteorites. This book is a fascinating autobiographical account that clearly delineates the single-minded purposeful persistence of a man who refused to be diverted by seemingly overwhelming obstacles from pursuing an almost impossible dream. Nininger's early prophetic vision of meteorites as scientific Rosetta Stones has grown to reality in his later years, a development that he substantially furthered by his missionary effort.

I am delighted that Nininger's experiences are now preserved in this volume.

As one among the few with a personal active scientific interest in shooting stars or *meteors* for some four decades, I have been amazed that he could indeed survive while persisting in his unique profession. His secret, of course, is exposed in these pages—a rare ability to communicate his knowledge and his enthusiasm, with an engaging rustic simplicity of approach. Applying this talent in the field, Nininger gains both the interest and the confidence of rural untrained people. If approached in a sophisticated or patronizing manner, they would become aloof. Furthermore, his basic honesty and integrity in his field activities stand out in his account, coupled, I must admit, with the shrewdness of a Yankee horse trader.

To illustrate his practical realism in the field, I recall his cooperation with me in a Harvard project at the White Sands Proving Grounds in New Mexico, December 1946. We were to photograph the first artificial meteors to be made by shaped charges in grenades exploded from a V-2 missile at high altitude. In his spare time while we were waiting, Nininger dug a "fox hole" as a personal safety precaution in case the unguided V-2 should land near our site, by no means an impossibility.

Nininger expresses his frustration at the lack of scientific interest in meteoritics before the middle of this century. I, too, shared that frustration, but in fact we both have profited by that lack of interest. It permitted us to work alone at our own pace in virgin scientific ground without much competition. Nininger wisely fails to recount some unhappy incidents where too vigorous competition actually thwarted him from receiving the just rewards of his efforts. Today, it is a pleasure and a satisfaction to see the tide turn as numerous young enthusiasts push forward the meteoritical research that we have long felt to be of vital importance.

It is not, however, just the search for solutions to practical problems of ballistics, missiles, satellites, and space probes—generated by the space age—that has produced the current impetus in meteoritical research; nor is it the availability of Moon samples. Advances in physics and chemistry have produced research techniques and methods of analysis so sophisticated and so subtle as to be almost miraculous when compared with the tools of research available early in this century. Today, the meteoriticist can analyze a sample the size of a pinhead to determine its composition and mineral content, its age since it was formed, since it cooled, and since it broke away from a larger parent body in space, its temperature and pressure at formation, and other details of its life history and, indeed, of the history of the solar system. Thus, meteorites are truly far more precious than diamonds, because they carry cryptic messages of happenings somewhere in the solar system more than four billion years ago. Oddly enough, we still cannot identify the parent body from which any meteorite was broken off. Presumably, meteorites come from asteroids by collision, and certainly they are of solar system origin. But where? To answer even this simple question, we may have to send space probes to asteroids and possibly even to old comet nuclei. As we seek these answers, Nininger's life work will serve as an increasingly important foundation. He has directed our attention both to the importance of meteorites and to the means of finding them. Now let us carry on from this accelerated start.

Thus, we all owe a debt of gratitude to H. H. Nininger for his successful educational program, both to the layman and to the professional, and for his material contribution of so many actual meteorites. In addition, we must thank him for telling us in such a vivid fashion the story of his life's work.

The life vividly exemplifies what he urged of his students, "Do something that needs doing."

Fred L. Whipple, Director

Smithsonian Astrophysical Observatory
Cambridge, Massachusetts

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# FIND A FALLING STAR

*What's past is prologue.*

*—Shakespeare*
*The Tempest*

# 1. THE PATH BEHIND

In the little village of Weston, Connecticut, in the year 1807, a certain Judge Wheeler stepped from his house early one December morning and was surprised to see a great ball of fire come riding out of the northern horizon. Dazzling, brilliant, sparkling, it nearly blinded him. He watched as it passed behind thin clouds and advanced to a point almost overhead, when it flashed three times and disappeared.

The judge was a learned, thoughtful man, and he was much interested in this marvelous spectacle that was different from anything he had ever seen before. He was very puzzled. It was like a "shooting star," only greater in magnitude. While he stood pondering, a great noise broke upon his ear.

It was like thunder, except that it grew louder and louder, grumbling and roaring in a most frightening way, almost deafening. While this sound still rumbled there came a second noise, a sizzling, whizzing buzz, as though something were falling. A little stone struck a nearby building and rolled away into the grass.

The judge, much perturbed, speculated whether there could be a connection among these three phenomena. It seemed impossible that a stone could have fallen out of the sky. Everyone knew there were no stones in the sky. How could there be? What would hold them up there?

Hosts of questions and a great puzzlement arose in Judge Wheeler's mind. He queried his neighbors. Some of them had also heard a sound, seen a light. A few had picked up odd-looking stones from their yards, wondering where they had come from. It was decided that some of the wise professors from neighboring Yale University should be asked to investigate. They came with misgivings, skeptical about the story that stones had fallen from the sky, fully prepared to dispel the peculiar and unwarranted assumption.

But as they interviewed Judge Wheeler and others they were impressed with the sincerity and awesomeness of their accounts. Finally, after prolonged investigation, the Yale professors concluded it actually must be true that stones had fallen out of the sky. They knew that these stones were different from anything on earth that they knew of, and they had witnessed extraction of some of them from holes in nearby yards and fields.

As had happened other times in the history of science, the impossible was found actually to have occurred. Stones had fallen out of the sky. The story, hard as it was to believe, spread. Eventually it reached the White House in Washington. The man who occupied the President's chair was himself a scientist as well as a statesman. When Thomas Jefferson heard this strange tale he declared it could not be true. Stones do not fall from the sky. At first the President treated the matter as something of a joke. But his informants insisted the stones had been seen to fall, had been picked up, that Yale scientists had investigated the report and vouched for its truth.

Thereupon, Jefferson, Southern gentleman, President of the new United States, whose words on science and on matters of state went far, spoke with great dignity:

"Gentlemen, I would rather believe that those two Yankee professors would lie than believe that stones would fall from heaven."

And that was supposed to settle the question. But eventually there had to be a fairer settlement, and the time arrived rather swiftly. During the next quarter of a century a number of similar falls of stones were observed throughout the United States. The scientific world became convinced that stones actually do fall. The name given them was "meteorites" because they seemed to be associated with the light phenomena that long had been called "meteors."

Similar failure or refusal to recognize meteorites as coming from "the sky," had been characteristic among scientists of Europe also, although acceptance of the fact in the Old World came a little earlier than in America.

In the middle of the eighteenth century an old French priest came to the Paris Museum carrying a stone which he said had been seen to fall out of the sky near his home.

"No, Father Nollet, you are mistaken. Perhaps you saw a flash of lightning which entered the ground near you and wrought a change in the soil to produce this stone. You yourself may readily see that stones *couldn't* fall out of the sky for there are none up there to fall."

And if any further evidence were needed to disprove the priest's claim, said the great scientists, it was readily available in the fields of logic, history, philosophy and religion. Certainly, if stones were to be expected to fall from heaven, then instruction to that effect would be found in the Holy Scriptures.

And so it was in France in 1751 that the question of "sky-stones" was settled, but just as in the young United States in the next century, it did not stay settled. A reliable astronomer, Jerome de la Lande, described a fail of stones near Bresse in 1753 and received no better answer than had the French priest. In 1769 another priest, Father Bachelay, presented to the Royal Academy of Science in Paris a piece of a stone he testified he had seen fall from the sky in Luce. The Academy was impressed to the extent that a commission was named to investigate the matter, the panel being headed by no less a personage than the great Lavoisier. Over that respected scientist's signature the commission reported that the stones in question were only terrestrial stones that had been struck by lightning which fused their surfaces. A bit of this fall has been preserved in the Vienna Museum.

An Italian chemist, D. Troili, wrote a lengthy description of a fall at Albareto, Italy, in 1766. His was a worthy account, but it fell on ears as deaf as those of the French scientists.

But then, as now, the "settled questions," the beliefs or unbeliefs of men did not disturb the ordered course of nature. There were other reported falls, in 1790 in France, in 1794 in Italy, in 1795 in England. There were numbers of witnesses. Stones were produced to prove their assertions. Finally it began to seem that where there was so much smoke perhaps there was at least a little fire, and scientists began to divide into two camps, one group contending the stones did indeed fall from the sky, the other still holding that terrestrial explanations could account for all cases.

Then on April 26, 1803, at mid-day, like a determined champion of forensics making one final effort to dispose of all negative arguments, Dame Nature hurled pell mell into northwestern France, only about seventy-five miles west of Paris, near the little town of L'Aigle, no less than 3,000 stones in a single shower. Hundreds of peasants witnessed the event, some narrowly escaping injury or death, and many were not a little frightened.

Now it was time for another investigation. A venerable commission undertook the task of studying the hundreds of reports, examining hundreds of the two to three thousand stones actually recovered. Scores of affidavits were sworn. At last the hard-headed scientists were converted and a decision in favor of the affirmative was rendered. Thenceforth it was permissible for a stone to fall from the sky into the soil of France without fear of witnesses facing embarrassment or self-doubts as to its celestial origin.

Thus the matter was settled finally among the leaders of the French scientists, but the question was far from being settled in the minds of ordinary persons. So far from being common knowledge was the matter that the conclusion of the French commission was not known to the Yale investigators of the Weston, Connecticut, fall four years later. It took a succession of several witnessed falls, over a score of years, for general scientific acceptance of non-terrestrial origin of meteorites, and all through the nineteenth century, and even into the twentieth, there have been scientific men who have doubted that meteorites actually fall, that it might not be just superstition.

One can understand why the fall of meteorites was a very difficult fact to comprehend and was so slow of acceptance by the world of science. The arrival of a meteorite might be witnessed by one person in a million. The living people of perhaps one village in ten thousand might experience such an event, with no more than one person in ten of that hamlet actually viewing it. Generations would pass without the occurrence being repeated. Meteorite falls are so infrequent that probably no community has ever experienced two falls in one generation or perhaps in ten generations. Not only are the events rare; they are unpredictable and of very brief duration. The majority of persons in the immediate vicinity of a fall will not be actual witnesses, but will only know of the happening by hearsay, or by earth tremors, sounds and momentary light flashes which merely produce puzzlement or even hysteria.

The celestial origin of meteorites was accepted by early people as a manifestation of the gods ages before it was accommodated by the practitioners of the natural sciences. Throughout his existence on this planet man has encountered meteorites. Time and again in ancient records are references to stones from heaven or from the gods. A meteorite that fell in Phrygia about 3,000 years ago gave rise to a religious cult that exercised widespread influence throughout the then known world. The principle shrine of the cult was in Pessinus in Galatia where a "stone from heaven" was kept in a cave under Mt. Dindymus. This was Cybele, "Mother of the Gods and of Men." The cult found favor among all Mediterranean nations. Cybele's supposed power was regarded so highly that when Hannibal had threatened Rome for fourteen years, successfully resisting the Roman armies' attempts to drive him out, the emperor in desperation consulted the Cybelline oracle and was told his only hope was to bring the great Phrygian stone to Rome. In the year 204 B.C. a special ship was built and an expedition set out to fetch the sacred object. The Phrygian stone was brought to Rome with great pomp and splendor. The revitalization of the army was immediate, and in a matter of months Hannibal and his troops were driven away. A temple for Cybele was erected and the worship of her cult continued in the western world for 500 years, posing one of the chief deterrents to the spread of Christianity.

One of the great yearly meteor displays, the Perseids, bears a second legendary name out of ancient history, "The Tears of St. Lawrence," in awe of the heavenly spectacle of August 10, 258 A.D., that followed the saint's death on a gridiron under the rule of Valerian.

The revered black stone in the Temple of Mecca, the Kaaba, is reputed to be from heaven, and whether a meteorite or not, its influence in

Mohammedan worship is due to this belief. Plutarch told of the fall of a meteorite in the year 405 B.C., and Pliny wrote 500 years later of seeing this great stone, still held in sacred regard.

The great temple at Ephesus was built for the worship of the "Image that fell down from Jupiter," told of in Acts 19 of the Bible.

Factual records were intermingled with all sorts of legends, superstitions and fairy tales. Then came the stirrings of the new sciences. The telescope was invented, the microscope. Everything began to be viewed in the light of demonstrable fact or mathematical theory. Legends and accepted notions regarding the material universe underwent critical examination and questioning. Many old assumptions could be readily evaluated, hypotheses verified or exploded by checking and rechecking of observed facts.

While science began its advances, religious views changed. The mythical cults dissolved into the mists of time and Christianity entered into battles of the True Word and Heresy. Reports of stones from the sky were classified as heresy, which in the days of stocks and witch burnings was a punishable crime. Of course there were instances where those of a scientific turn of mind were brought face to face with undeniable evidence, and, being convinced of the soundness of the case or at least forced into skepticism regarding the dictum of the "authorities," endeavored to bring the idea up for re-examination. This required courage and sometimes resulted in shadows being cast on men of respectability. No one can ever know how many authentic meteorites were disposed of during those centuries, never to be recovered.

To break through centuries of encrusted prejudice required wisdom, recognized scholastic standing and tremendous nerve. De la Lande failed, Father Bachelay also. Troili correctly deduced that the Albareto stone came from space, but his conclusion fell on deaf ears; other scientists rejected his worthy description and his reputation was imperilled. E. F. Chladni of Germany generally has been credited with being the first to evaluate properly the arrival of meteorites from space. As early as 1794 he published an able argument. Chladni gathered together a scattered lot of outlaw facts, sorted out pertinent reports and observations, made critical examinations of several "mysterious" and "miraculous" stones and hypothesized that these certain objects were not of terrestrial origin. Although his thesis was widely questioned and bitterly disputed by those who offered some earthly explanation such as vitrification by lightning, it was only a matter of a few years before the great L'Aigle shower of stones furnished cosmic verification of his theory.

But any accounting of men who have made great contributions to the science of meteoritics, the study of meteorites, must not skip over the work a generation earlier of Troili, Bachelay and their contemporaries, who defied an established order of thought to present credible accounts of phenomena universally adjudged impossible.

Tales and worshippings of stones or irons fallen from heaven "in old time" were prevalent among the American Indians. Superstition, legend, miracles and facts all were mingled as in the Old World in a more or less meaningless hodgepodge to be dealt with only by priest, oracle, or medicine man. A number of meteorites have been found associated with Indian relics in various parts of the United States.

My wife, Addie, and I have studied meteorites for many years, and among the many reports of possible meteorites that came to us from time to time there were some that, because of distances involved, we could not afford to look into immediately. We would answer the letters or make notes of oral reports, then file them away until several could be investigated on a single trip. One such report lay in our files for years. It was a message from George E. Dawson, writing from Phoenix, Arizona, that he had a 135-pound Canyon Diablo meteorite that he wished to sell.

Meteorites are usually named after the place where they are found, in this case Canyon Diablo, the site of an enormous meteoritic crater in Arizona. There are two basic kinds of meteorites; those mostly composed of an alloy of nickel and iron are called iron meteorites, or irons, for short; those primarily of stone are called stony meteorites, or simply, stones. For many years my wife and I supported our scientific research by collecting, classifying and selling meteorites to other scientists and to scientific institutions throughout the world.

Canyon Diablos—the iron meteorites found at the Arizona Crater—were the most plentiful iron meteorites on the market and we needed no more at that time, there being little demand for them during the thirties. I simply wrote to Dawson that I would stop to see his specimen when I was in the area.

It was a number of years before I hunted him up when passing through Phoenix. Yes, he still had the meteorite, still would like to sell it, but it was not in his possession at the moment. Query followed query about my connections and my reliability before finally I was told that I might examine the meteorite. Eventually the reason for Dawson's reluctance became evident. He had learned of the Arizona law which forbids digging into ruins—and this iron had been found in an old Indian grave. When I pointed out that the law had been adopted some seven years after he made his discovery, and that he had committed no wrong under it, Dawson led me to the rear of a curio store in downtown Phoenix where, hidden under some unimportant old relics, was the large iron meteorite he had been calling "Canyon Diablo" to escape any possible trouble with the law.

He drove me to an ancient ruin on a mesa top a few miles east of Camp Verde where in 1915 he had come upon a stone cyst—a little pocket in the earth walled and covered over with flat rocks—in the corner of a decayed dwelling. The little cubicle appeared to be a typical child burial cyst, but instead of a mummy, pride and joy of all pot-hunters, it had disappointed him by giving up, respectfully wrapped in feather cloth, a 135-pound metallic meteorite.

Thus did one of the first positive evidences of the American Indian's regard for things from heaven come to light.

Pottery associated with the burial showed an age of 800 or 900 years. Removal and study of the structure of a small sample of the iron indicated Dawson was very probably right in attributing his feather-wrapped meteorite to Canyon Diablo. Except for this small section, the meteorite remains intact, priceless because of its history as an object cherished by an ancient tribe of the human race. We gave it the name *Camp Verde,* for the locality of the grave in which it was found.

Only seventy miles north of the spot where Dawson found his iron meteorite in its Indian grave, Mr. A. J. Townsend opened another such child burial cyst to find not a mummy, but a pile of green-stained rocks which he judged to be copper ore. A University of Arizona scientist, however, identified the fragments as remains of a disintegrated meteorite which evidently had been seen to come from the sky and therefore was extended the respect of an honorable burial.

The little Pojoaque pallasite (stony-iron meteorite) was found in a pottery jar in an Indian burial ground in Santa Fe County, New Mexico in 1931. It bore evidence of having been carried in a medicine pouch, its surface indicating it had been subject to much wear against soft materials.

In 1950, while attending a mineral exhibit at Bozeman, Montana, we secured a meteorite from C. F. Miller that he had dug from an Indian grave in 1936.

Persistent field work accumulated further evidence that ancient Americans collected meteorites. The Horse Creek iron meteorite and the Springfield stone meteorite were both found in 1937 on Indian campsites in southeastern Colorado. The Elkhart stone (1936) was found on a campsite in southwest Kansas. The Alamosa (1937), Lost Lake (1934) and Newsom (1939) stones all were found by hunters of Indian artifacts in the eastern edge of the San Luis Valley of Colorado; Cotesfield (1928) and Briscoe County (1940) were found on campsites in Nebraska and Texas respectively. Muroc and Muroc Dry Lake of California (1936) were found in an area where Indian artifacts had been found. And the great Navajo iron of Apache County, Arizona, when found in 1922 had been covered with boulders, and bore several grooves that appeared to have been cut by stone implements.

Many other examples show ancient man's regard for meteorites. Certain tribes made regular pilgrimages to the meteorites of Red River, Texas; Willamette, Oregon, and Iron Creek, Canada. The Chilcoot meteorite was kept in the custody of an Alaskan chief. The Wichita iron of Texas likewise was held in high regard.

Meteorites were found associated with mounds of prehistoric Indians of the Ohio and Mississippi valleys. The Iron Creek meteorite was revered by Cree and Blackfeet Indians as the "Manitou Stone" where it lay on a hilltop in the province of Alberta, Canada. The great Casas Grandes iron, 3,407 pounds, was found buried, wrapped like a mummy, in ruins of the Montezuma Indians in Chihuahua, Mexico. The three great irons brought by Admiral Peary to New York from Greenland were objects of reverence among the aborigines of the island.

If the ancients had not seen these particular meteorites fall, they had seen others and had concluded correctly that these were of similar origin, passing the story down through generations.

This reverential treatment by Indian tribes of North America was in the same pattern of awe shown by other early peoples in many scattered places of the earth.

In India meteorites fell at Durala in 1815, Nedagolla, 1870, and Sabetmahet, 1885, and they were all worshiped to some extent, and the fall of Saonlod in 1877 was so feared that the natives pounded all the stones to powder.

The great reluctance to believe a fact of science was reserved for scientists, even for the first half of the nineteenth century in Puritan America.

*Apply your mind to at least one problem which has never been solved, which in general is considered impossible of solution, but which, being solved, would help humanity. Do with your life something that has never been done, but which you feel needs doing.*

# 2. THE CHALLENGE

In the early twenties I was teaching at McPherson College, McPherson, Kansas, where my wife and I were settled into the academic and community routine of small college faculty life. My specialty was biology, but I was also teaching a field course in geology. I enjoyed my work. Any problem that demanded critical observation intrigued me. I thought of myself as a *naturalist* in the older and true sense of the word—one who critically observes and describes facts of nature.

About the middle of August, 1923, in the *Scientific Monthly,* I found an article by Professor A. M. Miller of the University of Kentucky. The subject was meteorites. I cannot remember ever reading anything that so completely captivated me.

All during my childhood meteors were regarded in about the same light as ghosts and dragons: mentioned rarely and never discussed seriously. During my Oklahoma and Kansas student days I associated with field and laboratory scientists, yet I am sure I never heard the subject of meteorites mentioned more than once. On that occasion it simply was dismissed as "irrelevant." The word "meteorite" was scarcely a part of my vocabulary when I graduated from college and was almost equally unfamiliar after years of graduate study and teaching.

Dr. Miller's article indicated there was a body of knowledge of which previously I had read nothing except a few scattered paragraphs in the public press. It was a source of actual embarrassment to me for some days, for I had been in the habit of thinking that I was possessed of a pretty fair education.

Only a few months before, while attending a meeting of ornithologists in Chicago, I had walked with a noted scientist from a Philadelphia museum through the mineralogical hall of the famous Field Museum. We came upon the great meteorite exhibit and paused before a case of beautiful specimens.

My friend broke our silence "I wonder if they really know that these things come to the earth from space," he remarked seriously.

He had spoken my own thoughts. As I was to learn through succeeding years, he had spoken the thoughts of many scientists, including not a few geologists.

I reviewed Dr. Miller's article for our Faculty Science Club. Subsequently I spent many hours pondering the phenomena of meteorite falls and their uniqueness. It seemed to me that by any fair appraisal the arrival of a meteorite from space must be one of the most basic and fundamental of natural events. Here was a source of information concerning the universe beyond our atmosphere of a kind that astronomers were making no special effort to utilize. Here was a more or less contribution to our planet from outside space which geologists seemed to be making no effort to evaluate except as accidental recoveries were thrown into their laps.

What would I not give for the opportunity to witness the fall of a meteorite to earth! According to Dr. Miller's estimate, my chances were very slim, perhaps one in a million. Nevertheless I could not resist considering the steps one might take to determine the course and the approximate place of landing, and how one might go about obtaining community assistance for a search. Professor Miller had supplied no blueprint for such an undertaking.

Unknown to me of course, in August while I was first reading Dr. Miller's article, there was out in space a meteorite traveling in an orbit which crossed that of our planet at a point some millions of miles ahead of us; and the meteorite's speed and timing was such that we would reach that crossing at the same time. Most important for me was the fact that the side of our planet on which I lived would be turned toward the stranger at precisely the right moment to receive it. Of our hundred-million-square-mile hemisphere, only that half-million-square-mile area within which McPherson College was located would be permitted to experience the light display which would mark the end of the meteorite's flight.

On the evening of November 9, 1923, faculty and students gathered in the chapel for a lecture, play, chorus or some other of the programs common to college communities. At the close of the program I walked toward home with my friend Professor E. L. Craik. We paused in front of his house to chat. Astronomy didn't enter our conversation. Had anyone asked, I could have told that we were sailing along in our orbit at about eighteen-and-a-half miles per second, that our town and college along with all the rest of the earth's surface were in normal rotation about its axis at a little less than a thousand miles an hour. But I surely could not have told that a meteorite only a few thousand miles away was following a course that within minutes would mean the extinction of this minor member of the solar family before our very eyes and at the same time would start a metamorphosis in the life of a young biologist.

Suddenly a blazing stream of fire pierced the sky, lighting the landscape as though Nature had pressed a giant electric switch. The blade of light vanished with equal suddenness, leaving a darkness seeming thicker than before.

Momentarily Professor Craik was speechless. Then he saw that I was bent over, making a mark on the sidewalk. He asked me what I was doing. I remember telling him I was going to find that meteorite and that I was plotting its path from where I saw it. He laughed, but I was serious. I will never forget the conversation that followed.

"Do you really think that something has actually come to earth?" he asked.

I was certain of it.

"Well, where do you think it landed?"

"Probably within 150 miles," I estimated.

He laughed again. "Now I know you must be kidding."

"No, I'm serious, and I'm going to hunt for it."

"Has such a thing ever been done?"

It was the question that has followed me all of my life, thrown at me whenever I have proposed something new.

Professor Craik and I didn't talk long that night. I wanted to dispatch a message to the principal newspapers of our state. I asked the editors to publish a request to all who had seen the great meteor that had passed toward the southwest at 8:57 **P.M.** Central Standard Time to please furnish to me the following information:

1) The location from which the observation was made.

2) The exact direction of the fireball in relation to the observer when it disappeared, naming, if possible, some town in Kansas or a neighboring state which was in line with the path of vision.

3) How high above the horizon was the fireball when it disappeared or was extinguished—this to be stated in degrees, remembering that from horizon to zenith is 90°.

4) Was any sound heard in connection with or shortly after passing of the fireball?

Reports piled up, and so did my difficulties. As my file began to bulge I called in Professor Charles Morris of the physics department, who had surveying instruments and knew how to use them. We met in my laboratory on a Saturday to digest the reports that had accumulated.

A hundred and fifty miles from McPherson, near the end of the November 9 meteor's flight, people had been frantic. They had leaped from their beds and rushed from their houses in the belief their homes were afire. Men on the highways stopped their cars, blinded by the flash of light. Livestock crouched in fear. Children cried and women prayed. A few moments later, the sounds of blasts and a thunderous roar seemed to confirm fears that the end of the world had come.

One can readily imagine that a farmer, merchant or other person dazzled for the first time in his life by the spectacle of a great fireball might have some difficulty reporting the experience with accuracy. People wish to be helpful on occasions of this kind. So instead of merely supplying the simple information requested, the writers offered more. Why should a man satisfy himself with saying simply that the object disappeared in the direction of a town sixty or eighty miles away, when he could tell me the site, within a hundred feet or so, where the thing actually had struck? Or so he thought.

This was precisely what most of the reports set out to do. When Morris had waded through a dozen or so such letters from correspondents representing every corner of Kansas and localities in Nebraska and Oklahoma, each claiming that the meteorite's landing place was within sight of his house, he threw up his hands. There was no use wasting time on such a hodge-podge of conflicting reports, he insisted. He was used to working with accurate data that could be measured and weighed; certainly no good could come of struggling with this packet of misinformation.

Subsequently I learned that other scientists during the past century had, like Morris, turned away from such a confusing mass of reports and given up somewhat half-hearted attempts to trace down such a fall. But I reasoned that one cannot expect accurate data on such an exciting and even frightening event, coming as it does, unexpected and lasting only seconds. One can by careful screening select from a large number of witnesses those who will be most able to supply additional useful information through personal interview.

With an objective of such importance, one had better use whatever reports he has as best he can. I also reasoned thus: meteorite falls are important events—not mere incidents—and are rarer than comets; meteorites are tangible astronomical objects, not mere mysterious objects viewed from afar. In my opinion they were far more important than comets so far as either could be studied in that day.

So I used the correspondence as a guide to a mere rough approximation, judging from each letter whether indeed there was something of useful information that could be gained by talking with the writer on the spot where he had stood at the time of this exciting experience. By selecting the best half-dozen accounts and plotting on a map the reported observations, it was possible to build convincing evidence that the fall had taken place within a fairly constricted area, perhaps forty miles across. The indicated location was not that expected by any of the observers but was that where the lines of all the sightings taken together converged.

A commander of artillery has difficulty in scoring a good percentage of hits on a target ten miles away, even though he knows the exact location of the target, knows atmospheric conditions, direction and velocity of air currents, shape and weight of his projectile and velocity with which it leaves the muzzle of his gun. Trained technicians carry out his firing orders and trained observers correct his judgment.

In Kansas, in November, 1923, no one had expected arrival of the meteorite. No trained observers were scanning the skies to record its passage. I had to depend on the memories of startled laymen, who recorded their observations or were interviewed several days after the event.

Most observers were 100 miles away from the passing light. Somehow the course must be ascertained and projected to a striking point on the earth. I did not know the speed of the projectile, nor its size, shape, specific gravity. I could only approximate velocity, height and course. I did not know if the path changed somewhat after burning out. I could assume that the meteorite would fall a little more directly as it slowed. But I knew nothing of air currents or atmospheric conditions. The entire lighted course was limited to those parts of the atmosphere which were above the region of exploration of meteorology of that day.

I had marked the line of disappearance of the meteor, as I had witnessed it, as just behind a branch "next to the top of the pine tree in Mr. Price's yard down the street."

I added to my own observation the written reports that seemed useful. Then, in interviewing witnesses, I found that by having them point out to me stars, nearby objects or perhaps the branches of trees through which they had looked at the fireball, I was able to determine a consensus as to the altitude of the meteor's disappearance. By studying the course, the seeming velocity, reports of an explosion and description of accompanying sounds, I reached the conclusion that one fragment had fallen in the vicinity of Coldwater, Kansas, and that another, though with less likelihood, might have fallen to the north near Greensburg.

The best that I felt could be hoped for was the designation of a township (six miles square), perhaps half a township, in which fragments might have landed. But how to search half a township? One fact favored me. Meteorites were known in many cases to burst when passing through the air, scattering in fragments over an area of up to fifty square miles. This multiplied the chances of finding a part of the fall. Even taking the optimistic view and assuming there were a dozen or fifty fragments, how could one go about searching such an area?

Everyone has suffered frustrating experiences in searching about his own premises for some lost or only mislaid article. Consider expanding the area of search to even one square mile. If I were to take a piece of a brick and bury it a few inches in the ground, announcing it was buried on a certain square mile, how many searchers would come forth even if, instead of a piece of a brick, it were something of value? Most persons would see little use in searching. In spite of the slender chance of making a find by direct search I couldn't resist a try, and I took three or four volunteer students on a week-end search. We found nothing.

I conceived a plan to take the public into my confidence and form a sort of partnership with residents of the area in which I believed the meteorite might have fallen. During late 1923 and into the autumn of 1924,1 made several excursions into the vicinity of Coldwater and Greensburg, Kansas, visiting schools, asking cooperation of the press in printing appeals. I explained the nature and behavior of meteorites and the reasons they are valuable for study, then offered to pay a good price for any specimen found. I counted on this incentive to alert the whole community to interest in the meteorite. So far as I know, this method had not been used before.

The plan I followed in 1923 is the one I have used ever since. And until such time as provision shall be made to secure instrumental data by means of automatic devices I am convinced that this is the only method for successful "chasing" of fireballs.

Ultimately there were two meteorites recovered in the vicinity of Coldwater. I now credit neither of them to the fall I witnessed. Rather, I credit their finding to my alerting of the public.

On one of my first visits to the general area, in parts of two counties, where I was concentrating on gathering data in an endeavor to pin down the fall to a smaller target, I decided to use a Sunday morning to try for an opportunity to speak to a church group. I got to the church just as the crowd was coming from Sunday School classes and gathering for the preaching service. An usher carried a note for me to the minister asking permission to make a three-minute announcement. He kindly extended me the courtesy. In exactly three minutes I requested those who had witnessed the great fireball on November 9 to see me at the end of the service. Then I joined in the order of worship.

At the close, Deacon A. M. Brown came to me to say that he had not witnessed the fireball, but that from what I had said of the nature of meteorites he thought he might have one in his back yard. He took me to his house and showed me a forty-one-pound meteorite, an oxidized nickel-iron, that he had plowed up four years earlier. He said he always had wondered what such a heavy rock was doing in a field all by itself.

It was evident from the rust that this meteorite had lain on the earth a very long time, but the thrill it gave me can never be described. I purchased Deacon Brown's' meteorite then and there, paying one dollar a pound, the price I had determined was customary.

Eleven months after my 1923 fireball, a man plowing his ground bumped into a stone which seemed very unusual to him. He brought the rock to town to show it to the local editor, who wrote to me immediately that there had been found "a piece of the meteor that I had been hunting."

On my next opportunity, while on my way to collect fossils in Clark County, with H. T. Martin of the University of Kansas, I stopped in

Coldwater to examine the fragment. It proved to be an eleven-pound stony meteorite. It was found fifteen or so miles south of the course of the meteor as I had mapped its flight, and I had reservations that it might belong to a different and earlier fall, since it showed some evidence of weathering, but I tentatively assigned it to the fall of November 9, 1923. The newspapers, however, for the most part did not repeat my qualification, being more satisfied to say that the wild star chaser had made a catch.

In these days one would not need to be so puzzled as I was. The approximate time of the meteorite's stay on earth could be determined by isotopic studies. Even without such modern aids, I soon learned to recognize the effects and degree of weathering in a rough way. It was not long before I determined this was not a fresh stone, but one which had lain in the soil for many years before it was struck by the plow.

Handel T. Martin, my companion on that visit to the *Western Star* in Clark County when the smaller Coldwater stone was obtained, was a respected fossil preparator and a congenial associate on fossil-hunting expeditions. We were checking out a new fossil discovery that had been reported to me during my meteorite-hunting forays. During the trip Martin related a most interesting account of a meteorite find he had made twenty-some years before.

He was at the American Museum of Natural History in New York City, visiting with the curator of minerals, when Dr. H. A. Ward walked in, having just returned from a trip abroad. Dr. Ward as usual was dressed in his solemn Prince Albert coat, in the tail of which were pockets. Ward drew forth from one of these pockets a fist-size stony meteorite which he offered to sell to the museum curator.

Martin, too, examined the proffered specimen, and said,

"I know where there is a big one out in Western Kansas."

His story was received with some evident misgivings, but Martin was a careful observer and, now that he had learned something of the value of meteorites, he decided on a definite course of action. He wrote to a young man who had assisted him in field work a few years before, telling him just how many miles to go south from the town of Gove, then east to the corner of Farmer Brown's northwest forty, through the wire gate into the pasture and down the fence to a small branch of such and such a creek, then northeast along the north bank of the stream about 200 yards. There he was to find, lying half buried in the buffalo grass sod, "a big, dark brown rock."

Martin's final instructions were just as explicit.

"Load it in your wagon and take it into town and ship it to my home address."

Thus the sixty-five pound Jerome, Kansas, meteorite was recovered and preserved. It is now in the Yale collection.

*2*

That November night in 1923 when the sky suddenly was cleft by a shaft of light half as wide as the moon and far brighter, I did not suspect that the event would change my whole life, but almost immediately I felt certain effects. Apart from the excitement of trying to plot the course and recover the meteorite, I found myself completely engrossed, during all the time I could spare from my college and family duties, in an effort to learn as much as I could, as fast as I could, about this new subject. I consulted all the references available, ordered literature, consulted all my professional acquaintances.

The search for information was less rewarding than had been my search for the meteorite itself.

I wrote to the Field Museum in Chicago for information and was rewarded with a copy of Dr. O. C. Farrington's *Catalogue of the Meteorites of North America,* published by the National Academy of Science in 1909. Here was a great fund of information on all of the falls and finds that had been collected previous to 1909. I studied it avidly, and found that a generation before my time, in the eighties and early nineties, the state of Kansas had yielded more than her normal share of meteorite finds made within the borders of the United States in the past few decades. Among these finds had been the largest stony meteorite recorded in the world up to that time and, also, the greatest pallasite (stony-iron meteorite) ever collected. Surely the University of Kansas at Lawrence would be a fount of knowledge.

I gathered together enough cash for train fare and a night's lodging at a third-rate hotel and set out fully confident that I would return with useful information.

During my frantic search for the November 9 meteorite I had come across two farmers who had in their possession small meteorites from a recognized fall for which they had failed to find a market twenty years before. These I had managed to purchase with borrowed funds. They gave me the reassurance of first-hand knowledge and I carried them with me in my brief case.

The train's wheels could not turn fast enough. Every station stop bored me on that trip to the university. Professional pride demanded that I fill the wide gap in my knowledge of the world about me.

I was dismayed when members of the geology department at the university were unable to answer any of my questions. They not only professed ignorance of the subject; at first they showed total lack of interest. They showed me one meteorite specimen on loan from the astronomy department where it had lain unlabeled for years. They believed it to be the Tonganoxie, Kansas, meteorite, but were not quite certain. I looked at the forty-pound specimen and saw instantly it was a pallasite. Even I had learned the conspicuous difference between pallasites (stony-iron meteorites) and siderites (irons), and knew that Tonganoxie was a siderite. This could not possibly be a part of any recorded Kansas meteorite other than the Kiowa County or Brenham fall that had been discovered in 1885 and described five years later.

I headed for the astronomy department. When the professor emerged from his office to learn what he could do for a young teacher from one of the state's small colleges, I stated my case with great confidence that here at least would be a source of facts.

Somewhat apologetically, the astronomer told me he had but one meteorite specimen, a small slice he personally had purchased from a supply house some years before. He produced an etched slice of one of the most common nickel-iron meteorites and gave me a rough approximation of its chemical composition.

"But I would like to learn more about stony meteorites," I told him.

"Stony meteorites? I didn't know there were any."

On my way home, I considered the matter. My first reaction was great disappointment that these men had proved to be ignorant of this unique and, by its very nature, fundamental aspect of our universe. But on second thought I realized that inasmuch as these men had been trained in the best universities of our land, they must be fair examples of a situation that pervaded our whole educational system. The subject of meteorites simply wasn't being taught.

I was both appalled and challenged. Newly introduced to the subject of meteorites, I was finding that in such a state of affairs, and in comparison with others then on the science scene in Kansas, I was not far from becoming an "expert," due only to my avid reading of whatever I could lay my hands on and the fact that I was making some personal field investigations.

As nearly as I could find out the principal reason for the dearth of information was the scarcity of meteorite finds. Although Dr. Miller, in the first article I had read on the subject, had written interestingly and informatively about meteorites, in no place did he indicate that the subject was of real importance. Since initial recognition of meteorites by science in 1803, only fifty-three falls had been recorded for the entire United States—an average of one in a little more than two years. If I could peddle my enthusiasm to enough people, in enough places, I believed I could modify these statistics considerably.

It had taken much of my time for almost a year to locate and recover the two Coldwater stones. Whether I could speed up the recovery process in some way I could not tell, but I hoped that as I gave lectures in rural high schools and grade schools, the farm children who attended those schools would spread the word among their parents.

The literature was full of stories of meteorite finds made purely by accident. Surely a planned strategy of educational propoganda would increase the number of such finds. If the residents of our state of Kansas could be kept alerted as to the nature and importance of meteorites, it seemed to me that a far greater number would be brought to light, especially if an attractive bonus were offered for each find.

But I was a biologist, I reminded myself. Meteorites should be the concern of astronomers and geologists. But, if nobody has been trained to observe, collect and study them, then a biologist, I decided, might just as well start working on the subject as anyone else, especially since astronomers and geologists seemed for the most part to be otherwise occupied.

How could the population of a state of 81,000 square miles be alerted properly? How could a proper program be financed? Surveys and searches were expensive. When I took $41 from the budget of our growing family to purchase Deacon Brown's meteorite, I started spending sleepless hours wondering how I would finance this new hobby that had become my consuming interest. I ran into financial walls. All small colleges were struggling to maintain their meager programs. Universities were better financed, but their funds had been committed. This idea of mine was so unorthodox that no one could, or would, justify its receiving attention while many other programs, some of them widely recognized and considered of far greater importance, went unsupported.

Any program I could carry out would have to be self-supporting. I turned to my experience as a natural-history lecturer. I estimated that I could schedule one or two appearances a week at points not too far distant from McPherson. President Daniel Webster Kurtz allowed me to carry a light teaching load and devote as much time as I considered advisable to my research program. Lectures seldom paid much more than travel expenses. My hope, though, was to arouse interest that, in turn, would result in location of new meteorites. The catalogs of scientific supply houses showed that quite high prices were charged for meteorite specimens.

In addition to providing a hoped-for source of support for itself, my search for specimens was intended to test what I considered an unwarranted assumption as to the scarcity of meteorites *in the soil,* and the rarity of *falls.* The experts had said that the scarcity of meteorites was a fact; and that was that.

Were my two finds at Coldwater a mere case of beginner's luck? I could not believe so. There just was no logical reason for believing that meteorites fall more frequently on one part of the earth than another. Yet intensive search had yielded two falls of unknown date in a county where I had cause to believe still a third meteorite lay undiscovered.

Here was the other side of the coin or, perhaps, here was another application of the old chicken and egg riddle. Did lack of knowledge really come from a paucity of specimens? Or did the extreme rarity of meteorites reflect a paucity of knowledge?

The complete neglect of the subject of meteorites in all curricula had rendered the population helpless to recognize them except in extremely rare instances where some farmer or ranchman had inherited an unusually large curiosity bump and then luckily had met a scientist who knew and told him something about meteorites.

Deacon Brown's meteorite and the smaller Coldwater stone, found in a period of less than eleven months, were twice as many meteorites as had been recorded for the entire state of Kansas during the fifteen-year period just previous to 1923. The interest and publicity attendant on my survey and search must have been responsible for their recovery.

I came to believe that discovery of the older stone actually was more significant than would be the finding of the actual meteorite of November 9. The two Coldwater finds demonstrated a fact which I then already suspected and since have come to recognize as a rule—that meteorites are widely distributed over the earth and that any considerable search of a territory of considerable size will probably result in the discovery of a new meteorite.

*If, when the sense of life commands a turning, you play the game, though new, with zest, and though upon the field you stand alone, the day may come when those who scoffed will court you, will lift you up. One change succeeds another; the best oj life lies in its sober days.*

# 3 FINDING A WAY

Although I wanted to give meteorites my full attention, for a while I knew it would be necessary to hold my teaching job, lecture for fees, do as much field investigation as I could manage, and sell specimens as I obtained them.

I had been able to pick up a few bargains in meteorites by purchase, but what I had counted on being *found* as a result of my educational program just had not materialized.

Painstakingly and sometimes painfully, I investigated lead after lead, only to have each turn out to be a dud. Some of these abortive reports sounded so infallible that it seemed investigation could not possibly fail to produce great finds.

During my early survey of the Coldwater fireball in 1923 and 1924, a former resident of Hodgeman County, about sixty miles north, told me that when she was a small girl of eight or nine, she and other children used to play on a large meteorite that lay in the bottom of a hole some three or four feet deep—a meteorite that her father and neighbors had seen fall. Her description of the object was convincing. Various members of the family had made futile efforts to take samples from the mass, but failed, and since they knew of no use or value of the thing anyway, nothing further was done about it. The family moved during her teens and she knew no more.

In later years I would have placed such a story on a waiting list for future follow-up when I happened to be passing that way, but in my inexperience I viewed the report as a *must.* Such a find might enable me to balance my budget, which was wearing thin from all my running around. So I made the trip to Jetmore, the county seat, via train and hired car. By eating cold lunches and sleeping in cheap rooms, and by delivering a ten dollar lecture in a high school en route, I managed to pay nearly half the outlay, but the remainder meant more red ink added to the cost records of my meteorite hunt. I was able to find absolutely no trace of substantiation for the story.

*Mr. Charles H. Hanington, President, Board of Trustees, Colorado Museum of Natural History who always took an encouraging interest in the author's meteorite work.*

*Dean Gillespie, a meteorite enthusiast who often financed field trips for one-half interest in the proceeds, if any.*

Travel itself was difficult. There were practically no hard-surfaced roads and most of the rural ways I was forced to use were not even graded. Cars were slow, tires were untrustworthy. The possibility of rain storms made use of these back roads very hazardous for one who must face classes Monday morning. I made most long trips by train, but meteorites, and especially the duds, seemed always to lie in the most out of the way places.

In 1922 I had purchased an already old Model-T. It had no arrangement for carrying spare tires; instead, I carried a good set of tire tools and patching materials, and certainly made good use of them. I would mend tires in ankle-deep mud while a raw wind numbed my fingers, or creep in low gear through mud for hours toward a remote farm house, only to find an ordinary rock instead of a "solid iron meteorite."

Were the old scholars right? Was my idea wild and unworkable? Many a weary hour I searched my plan for flaws when I would rather have slept, but always I arrived back at the same conclusion. I went back through a hundred years of records of meteorite discoveries. If those records told me anything between the lines they told me that the only reason meteorites were not found more frequently was because people just didn't recognize them. I continued to trust that one or more pairs of the thousands of eyes I was training in the rudiments of meteorite recognition would come across a specimen in the course of routine duties on farm or ranch, but somehow I must support and further my interest in meteorites until specimens began coming to me. So I arranged to take extended leave of my classes for the fall semester of 1929 in order to go to Mexico, where I hoped I could acquire a number of specimens for stock in trade.

Since I had found the literature on the subject of meteorites so inadequate, I decided the best preparation I could undertake was to acquaint myself as thoroughly as possible with known American meteorites. Mostly by means of two extended family trips I had managed to examine the major collections at Washington, Chicago, New York, Harvard, Yale and Amherst—nearly all the collections of any note on the continent, with the important exception of that in Mexico City, which held five of the greatest meteorites in the world.

Except for Castillo's *Catalogue of Meteorites of Mexico,* 1889, there had been almost no contributions to the literature on meteorites by Mexican scientists, although a valuable body of meteorite writings previously had been built up in that country. Geographically, a greater incidence of meteorites had been recorded in Mexico than in most parts of the United States—a reflection of active interest.

At some time during the years he was the dictator of Mexico, 1884-1911, Porfirio Diaz had issued an edict that all meteorites found would be considered government property. Actually quite a few meteorites had been found in Mexico and had been reported in the United States and elsewhere, but they had not been reported to Mexico City. I felt certain that more had been discovered since and could be obtained by purchase, and I was confident I could secure a permit to remove such finds if I had attractive exchange specimens to offer.

In some ways the time was not very propitious for going into that country in 1929—there had been a revolution the year before—but Mexico offered a clear challenge and a possible resource, although revolutions then occurred in Mexico with almost the regularity of elections in the United States.

So I began to plan a trip. My wife, Addie, and I were in debt as usual, but there was nothing crowding us, and we had credit at the bank. I would take out extra insurance, and my teaching salary would continue through the Fall semester of 1929 while I would-be away. I approached Alex Richards, one of my students, about going with me. He spoke Spanish fluently. He was twenty years old, resourceful, personable and unafraid of hardship. Alex set about getting together $200 to match mine.

Alex had mechanical experience and aptitude; his favorite reading seemed to be *Popular Mechanics.* I asked him to construct an automobile of the most rugged sort, made up of parts of other cars. I directed him to make a real husky car, a very ugly one, that nobody would want to try to steal. He succeeded better than I thought anybody could. No "hot rod" ever looked quite as tough as that car. It had seven speeds ahead and five backward, extra clearance and a skid plate to protect its vital parts.

When we reached the border town of Laredo, Texas, in September, 1929, we went to the Chamber of Commerce and asked for advice and information. We were told nobody drives to Mexico City, and nobody camps in Mexico. We were warned of a veritable scourge of banditry in Mexico. We would be robbed and then murdered to prevent the crime being reported.

The Chamber of Commerce man went on to tell us we would not see a signpost or a road after leaving Monterrey. He warned, lectured, pounded his desk. Finally, he marked on our map—not a road map, just a common geographic map—the areas where banditry was reported to be the worst. He cautioned us about food, water and disease. He inspected our Winchester automatic rifle and told us we would need it—if the authorities would permit us to take it along. He tried in every way he could to be helpful, at the same time gesturing resignedly and clucking concernedly. We would never, he declared, reach Mexico City. Or if we did, we would never return.

Alex and I mustered our courage. We had made so much preparation we just would not turn back. We carried camera equipment to record our experiences, a selection of meteorites for exchange and a great cargo of food supplies and other paraphernalia. We laid out everything in the glaring sun on the International Bridge across the Rio Grande for the inspection of Mexican border officials, who looked over each item, down to the salt and pepper shakers, with courtesy, consideration, and delay.

The first 150 miles into Mexico was on graveled road. The Laredo-Monterrey leg was the only strip yet opened to traffic of Mexico's national road building program of 1929. As we climbed from Monterrey and emerged through a mountain pass onto the great desert plateau that occupies most of northern Mexico, we passed the last of the road workers.

Our route to Mexico City led south from Saltillo, via San Luis Potosi, but we wished to visit Torreon, some 200 miles across the desert to the west. Our first three days out of Saltillo were spent in a dreary search for the right trail. Then the thirsty desert surprised us with a truly beautiful oasis, an amethyst pool set in the dryland matrix, fringed by marsh grasses and guarded by a lone stately cotton wood. This watering place was so welcome we stayed a full twenty-four hours, filling our radiator, catching up on laundry and collecting jars of insect specimens. From Torreon we visited Jiminez, where large meteorites had been found a century earlier, then returned to Saltillo by another way and continued on toward the capital city.

We averaged forty miles a day, some days covering a hundred, some days as little as ten miles. We would stop by the roadside, usually near a village, and light our gasoline stove. Most evenings we prepared flapjacks. By the time our fire was going well a crowd of onlookers would be thick around us, not unfriendly, but curious, watching with some fascination the tossing and fielding of flapjacks in mid-air.

At noon or evening, if we stopped far out from any habitation with not a soul in sight, it was disconcerning to bring out our lunch and then look up to see suddenly a couple of men standing among the desert shrubbery just a few steps away. Perhaps if we turned we would see another visitor staring at us from behind a bush. We usually would manage to lift our rifle into view while ostensibly searching for some item among our supplies.

One day we were interrupted at noon by a proud and tough-appearing caballero, heavily armed, who sat staring while we ate and then followed us for several miles when we started on. We were glad when he dropped behind.

One sundown found us, weary, in bandit country, and as we had seen no house for a long way we picked a spot almost clear of brush and began setting up camp. Suddenly a very unfriendly looking character approached, then another showed up, and another. We managed to catch their interest with some trifle from our pack, then quickly replaced our gear and drove on. Long after dark we reached a hacienda surrounded by a high wall with a guard at the gate.

We showed our credentials. The guard hesitated, then sent us on to a second gate that opened through another wall. Here we waited while this gateman took our papers to yet a third gate near the big house. After some time we were allowed to pass on to the final gate that opened to the ranch headquarters. Now a man from the big house, who spoke some English, came out to us. He examined our papers carefully, looked over our pack and invited us to drive into the passage that led to the central court. We parked according to his instructions and, being terribly hungry, had begun eating a cold supper when up drove a big, old-style Buick, loaded with police, all armed and with machine guns mounted on the running board of the heavy car. Two officers jumped from the car, demanding in Spanish to know who we were. We referred them to our host, who spoke to them at some length. Again we showed our papers; Alex answered questions. After inspecting our gear the police went their way. Our host told us they were searching for bandits who had killed a man that afternoon on a neighboring hacienda. We were not questioned further.

We spent the night there and continued on the next day, arriving in Mexico City the day following.

The first place Alex and I visited in the capital was the *Instituto Geologica.* We knew no one there and carried no letters of introduction. When we asked about meteorites we were directed to Dr. Frederick K. G. Mullerried. The short, stocky German geologist was a great field investigator who had traveled all over Mexico and later explored New Guinea. He had discovered a hitherto unknown volcano and a new species of fossil in Chiapis, a Mexican state bordering on Central America.

I explained to Dr. Mullerried that I had read accounts in the scientific literature of the large number of iron meteorites found in Mexico, and asked if he could tell me how to learn something more about Mexican meteorites.

"I think you have come to Mexico at a fortunate time for you," he told me. "No one in Mexico is studying meteorites. There are a number of meteorite falls that never have been classified."

He arranged for me to see all the specimens in the National Museum. Immediately I saw that some were mislabeled, some unlabeled. During times of revolution things had a way of getting mixed up, mishandled, even lost. I offered to write descriptions of some of the undescribed meteorites, correct the errors in labeling and help to put the collection in order. The museum officials were glad to have this done and arranged also for exchanges of their excess materials for the trading specimens I had brought with me in hope of just such a possibility.

For several weeks Alex and I worked in the museum cutting samples from unidentified meteorites, polishing and etching them to establish identification, labeling, making notes on various specimens including the history of each find.

Here was a use for the skill in which I had been training myself, the ability to identify the correct origin and classification of nearly any meteorite specimen by surface features and by the etched Widmanstatten pattern (which often appears when an iron meteorite is cut, polished and etched with acid).

In the course of my readings about meteorites my attention had been captured by the story of the so-called Toluca fall of Mexico. When Spanish settlers first visited the little village of Xiquipilco near Toluca and Mexico City in 1766, they found the natives making implements out of native iron. At this time the existence of meteorites as matter from space had not been affirmed by the scientific world. The Xiquipilco community h*d no manufactured metal; the natives told visitors they "always" had made their tools from iron picked up in the fields.

A quarter of a century later, when the arrival of meteorites on earth had been confirmed, collectors remembered that distant Mexican village. By 1824 visiting scientists had obtained specimens. The natives then still were using iron fragments from their fields for making implements, but the creation of a market for the meteorites soon led them to obtain man-made steel for their tools and they saved the natural iron for sale to visitors. In the latter part of the nineteenth century great quantities of the material were shipped from the area. Dr. Jose Aguilera, a noted Mexican geologist, told me in 1929 that no less than twenty-two tons had been shipped out prior to 1906.

One of the burning aims of my developing interest in meteorites was to visit this village of Xiquipilco. Foote and Ward, two mineral dealers who had done most of the collecting in that area, had died shortly after the turn of the century. There was nothing in the recent literature about the Xiquipilco meteorites, and Mexico had been in revolutionary turmoil. These three facts indicated there might be much to gain from a visit to Xiquipilco. Perhaps this village, apparently unvisited by a collector for twenty-five years, would yield specimens at a cost that would enable me both to augment my personal collection and add to my exchange stock.

I spoke to Dr. Mullerried.

"While I am here I would like to go over to Xiquipilco where they found so many irons."

"Oh, that's true," he said. "They did find many meteorites, but I haven't heard of anything coming from there for years. Besides, that's dangerous country."

He was not sure it would be wise for us to try to go but he promised to make inquiries.

From time to time I would ask him about it, but he never offered any encouragement. When I mentioned that I should like very much to locate one of the implements that were reported to have been made from meteorites at Xiquipilco, this interested him somewhat more, but still he fostered little hope for the trip. I told him I was set on going even if I must go alone.

At last one day he announced that he had made arrangements for the trip if we still wanted to try it. At this time Alex was seriously sick with amoebic dysentery. Dr. Mullerried himself prepared to go with me.

The little village of Xiquipilco is only about thirty airline miles from

Mexico City, but it lies across extremely rugged mountains. We were to go by train to the city of Toluca, take another train to Ixtlahuaca and hire some sort of conveyance from that point.

Before we left Mexico City I cashed a fifty-dollar American Express Travelers rheck so that I would have some negotiable money to buy specimens. In 1929 all Mexican money was silver. A peso was worth twenty-eight cents, and by the time I had loaded up with pesos from my check, together with the pesos I had already, my five pockets were bulging. The coins weighed me down and every time I took a step they jingled.

"Can't you keep them from rattling?" Dr. Mullerried would groan. "We'll be robbed here going down the street with such a jingle of money."

He managed his silver supplies better. His own pesos were rolled up in his field clothes and stowed in his knapsack.

We stayed the night in Ixtlahuaca. Dr. Mullerried scouted around inquiring about the possibilities of locating meteorites in Xiquipilco. He came back reporting no luck, and even suggested the trip appeared so futile and dangerous that he wondered if we shouldn't abandon the idea. Dr. Mullerried was a brave man; I knew that I must take his doubts seriously; but I couldn't give up.

"I am a long way from home," I told him finally. "I've come down here at considerable expense and difficulty, and I think I'll go ahead and try it alone if you don't care to go with me."

As I was hoping and expecting, he wouldn't let me go alone. He sent out runners to find someone with a truck to take us on to Xiquipilco. Late that evening a man appeared who said he had a truck to take us, and Dr. Mullerried engaged him for five o'clock the next morning. Almost immediately another man arrived who also had a truck, and Dr. Mullerried hired him for five o'clock the next morning. A third man appeared and the same scene was repeated.

"What in the world are you doing?" I asked. "There are only two of us to go."

"This is the way we do in Mexico," he answered. "We will do well to get one truck. Worry about getting one, if anything."

So we got up the next morning at five o'clock. A truck appeared at 6:00 and we went. The road was terrible. Wrecks along the way testified to many failures of vehicles to negotiate it. We made the drive of twelve and a half miles by 9:00 **A.M.**

At the village there was nobody in sight except one man, wearing a white suit and big, broad sombrero, standing alongside the church. Dr. Mullerried explained our purpose to him and we learned that he was *El Presidente*—mayor of the village.

The mayor listened with a puzzled manner, looked us over rather carefully and finally invited us to breakfast. While we breakfasted, the mayor left briefly and came back carrying a twenty-pound meteorite. Was this what we wanted? Dr. Mullerreid and I could barely contain our excitement.

"Do you think you can get more of this?"

"I think I can get you a ton."

Our host sent out a runner, and while we walked about, waiting for word to get around, I myself picked up a little three-pound meteorite in one of the fields. When we came back to the town square there were men standing with baskets and bags and handfuls of meteorites. For the next couple of hours we bought meteorites until we ran out of money and the Indians were still holding up meteorites to sell, crowding about like a bunch of ants around a bit of syrup. We bought 700 pounds of meteorites.

One of our last purchases was a *barreta,* a crowbar-like tool fashioned from a meteorite. It was market day and I had gone through all the wares displayed in the public square, looking for a meteorite shaped into some kind of tool, and finding none. Finally I visited the blacksmith shops. At the fourth and last blacksmith shop I recognized, on a tool way back in a corner, the Widmanstatten lines that proved meteoritic origin. The figures were warped and beaten out of shape, but they were visible.

"Where did you get that?" I asked the smith.

"I made it."

"What did you make it out of?"

*"Areolito,"* he replied—the Mexican word for meteorite.

Our visit was a glimpse into a distant and primitive past. The tremendous meteorite shower that occurred at Xiquipilco a hundred thousand to a million years ago marks that area as one of the most interesting in the world for any student of meteorites. It is the only place known where from time past remembering men had forged all of their crude knives, plows, hammers and other iron utensils out of iron from another world.

I was accumulating considerable information and a good supply of Mexican meteorites. While examining the National Museum collection I recognized that a small meteorite labeled as Xiquipilco was a mis-identified specimen and was able to determine that it came from Chihuahua City. Through correspondence after my return home I was able to obtain the main mass of that fall, over 100 pounds. Besides the Xiquipilco material and the Chihuahua City iron, I acquired specimens of Zacatecas, Chupaderos, Bacubirito, Tlacoptepec, Puenta del Zacate, Rancho de la Presa. The total was more than 900 pounds.

After making arrangements for shipping the meteorites back to McPherson, Alex and I prepared to return to the United States by train. First we had to sell our hodge-podge automobile. Regret was mixed with relief, for it was like parting with a fond, if somewhat crazy, friend. It had served us well.

Sale of the jalopy served as a sort of injection for our flattish billfolds.

We applied at once for passes on the National Railroad a combined freight and passenger train, on which we returned along the West Coast.

Back in McPherson, Kansas, shortly after the Christmas holidays, Alex brought me a meteorite about the size of a potato. He told me the twelve-ounce stone had been picked up by a neighbor, a youth who had heard me lecture about meteorites at the Paradise school more than four years before. A sixth-grader then, the boy had found the stone about four years later while in the field husking corn. He thought it "looked like what the little professor was talking about," he told Alex, and had brought it in with the corn. Then he got a little embarrassed at the thought that his family might laugh at him for such a notion and he tossed the meteorite into the cow lot. When Alex was at home between the end of our Mexico trip and resumption of classes the boy described the stone to him and they went out to the cow lot and retrieved it.

That little rusty fragment, picked up by a boy who had "listened" when I talked about meteorites, proved my plan workable. It had been nearly six years since the Coldwater, Kansas, fireball had inspired my program of lectures in the rural communities. The necessary element was time, a period for ripening.

I made a return lecture in the Paradise community, describing the find that had been made and suggesting there probably were other meteorites about. At the close of my talk, during the question and answer period, I noticed a young fellow leave by the back door. When he returned shortly afterwards, he carried a seventeen-pound meteorite that he had found the previous summer but poked under the granary so the family wouldn't ridicule him.

Within a few months a half-dozen meteorites with a combined weight of 140 pounds were recovered in the community and given the name of "Covert" for the nearest post office. All of these had been lying around for years and were only reported after it became known that a local boy had received money for his "rock." One stone had served as a doorstop. Another, weighing thirteen pounds, held down the lid of a pickle jar for twenty-five years. A thirty-one pounder had been used to plug a rat hole in a cellar. Then the house had been moved away and the cellar caved in; Alex helped sift through the rubble and the meteorite was uncovered.

The two Coldwater finds were the direct result of my personal contacts and through the press while making a fireball survey. The Covert meteorites were recovered as a consequence of a lecture campaign which depended on no phenomenal event to excite the people, but assumed that meteorites were widely distributed all over the world from falls of ancient and recent times. Education of the public in the importance of meteorite recognition and provision of a monetary incentive were features common to both efforts. The success that attended the first survey supported my faith in a general program, finally crystallized by the delayed reaction to the Paradise school lecture.

The Covert meteorites gave assurance that my theory would be fruitful, and I now determined to resign my teaching position as soon as my finances were in better shape, and devote my time to meteorites. I proposed to lecture, hunt meteorites and supply specimens to museums.

Since my guiding theorem was that the farmers and ranchmen of America know far more about what is in and on the soil than any group of scientists and thus are the logical source of greater supply of meteorites, my ways and means of extracting the information they could give me must be as effective as possible. Effective lecturing would answer the problem of ignorance and disinterest about meteorites, and by spreading knowledge and interest a community could lead to one find which might lead to another. The reward given for discovery would dispel any attitudes of ridicule or disbelief.

It became my standard practice to pass actual meteorites among the members of an audience so that all might examine them closely and hold and heft them in their own hands. It also was my practice to use laymen's language.

Experience showed that a strictly informative lecture could be made interesting enough to hold the attention of any group from fourth grade on up through high school and college. Gatherings of farmers and ranchmen, members of service or civic clubs, would also listen raptly throughout a forty-five minute presentation. Sometimes I would speak to groups of laborers coming off their shifts at mines or on road construction jobs. I would address farm workers fresh from threshing, cotton picking, hoeing the row crops. More than once I walked out into the middle of a field where workers were hoeing cotton to show them a meteorite and urge them to keep eyes open for something like it.

I was convinced there was going to exist a science of meteorites. Its foundation would be the field program which I believed I now was initiating through my project of lecturing, distributing literature and supplying articles to local newspapers, particularly in the Kansas farmlands. I counted on the purchases I was making to stimulate the farmers to look for additional meteorites, and was certain that once my program was well under way there would be demand for all the meteorites available.

For all intents and purposes the science of meteorites (had there been one) was dead in America by the mid-twenties save for the activities of two men—Dr. George P. Merrill of the United States National Museum of the Smithsonian Institution in Washington, D.C., and Dr. Oliver C. Farrington of the Field Museum of Natural History in Chicago. It is to these two men that I am most indebted, despite the fact that both had passed their prime years of activity in the field by the time I entered it. Each of these men carried the responsibilities of head of the department of geology of his museum. No institution in America had shown respect to the subject of meteorites by assigning a man officially to the field of meteorite studies.

It seemed a long jump for me in 1923 into the far corner of the scientific arena where geology and astronomy met, or rather where they came together. Neither geologists nor astronomers seemed to recognize meteorites as being worthy of full-time attention. A score of mineralogists, chemists'and geologists had made valuable contributions to the study of meteorites in the latter part of the nineteenth century, and a few in the earlier part of the twentieth; but none seemingly had visualized a real science of meteorites, i.e.: meteoritics.

Dr. George Perkins Merrill was the first scientist I made contact with after finding my first meteorite. I sent my first sample to the United States National Museum. Dr. Merrill had a keen interest in acquiring new meteorites for the national collection and during the remaining years of his life he obtained portions of each fall that I discovered. The U.S. National Museum was operating the only meteorite saw in the country at that time. A meteorite saw is a special type of band-saw used to cut meteorites. When I acquired several fine specimens of the Brenham pallasite in the early twenties Merrill was glad to slice them for me in return for receiving half of each. It seemed a high price to pay, but it enabled me to acquire a number of salable specimens without laying out any cash beyond the original purchase price, which had been relatively small.

Dr. Merrill did not seem to relish the idea of new men taking up the study of meteorites. I cannot say that he ever encouraged me to undertake an investigation. He had been in charge of geology and meteorites in the great National Museum since 1897 and had worked in the department there for sixteen years before that. As I came to know him better I decided that he was interested in seeing that the national collection had portions of more meteorite falls than any other museum in the world, but that he was not interested in ascertaining, by field work, how much of any fall had reached the earth. When attempting to estimate the total amount of matter reaching the earth as meteorites, Merrill consulted the catalogs of meteorite collections in the great museums of the world.

On the other hand Dr. Oliver Cummings Farrington was not only a curator of meteorites, but also a great student of their structure, composition, distribution, origin, the phenomena of their fall, their size, their shape, everything about them. It was the reading and re-reading of Farrington's *Catalogue,* together with my own field experiences, that led me to develop the conclusions regarding the frequency and distribution of meteorites upon which my hopes for a collecting career were based. My ideas seemed radical to Dr. Farrington, although he took an interest in discussing any question I asked.

I visited Farrington many times and on the occasion of my final visit outlined to him my conception of what should be undertaken as a program of meteoritical research and the kind of institution that was needed to accomplish the plan. The old gentleman, then in very poor health, responded that he wished he were younger; he would like to help toward the realization of my dream. With his passing, the young science of meteoritics lost a great leader.

While in Washington, D.C. in 1928,1 called on Dr. Merrill at the U.S. National Museum to outline my ideas for a field program for the recovery of meteorites. I had hoped that the National Museum would recognize the virtue of such an undertaking and perhaps support it with the understanding that all of the meteorites discovered thereby would belong to the great national collection.

During our rather lengthy conversation Dr. Merrill's answers were all negative and finally, after my last plea, he spoke with emphasis:

"Young man, if we gave you all the money your program required and you spent the rest of your life doing what you propose, you might find *one* meteorite."

To this I replied, "Do you know what I'm going to do about it?"

Smiling, he said, "No, what?"

"I'm going back home and in some way—I don't know just how—but I'll raise the money and go ahead with the program and next time you see me I'll be selling you a meteorite."

He laughed and we shook hands. The next time I saw him I was selling him two meteorites! If he remembered, he never said so.

Some years later I again visited Dr. Merrill in Washington. I reminded him of the Rosebud stone, a very interesting meteorite in Texas which I suggested he might be able to acquire by exchange or by purchase and which would be a wonderful addition to the National Museum's collection. He said that he didn't believe he would be interested. "I think meteorites have already given me just about all they have to offer by way of information."

The story of the Rosebud meteorite is indicative of the confusion and disinterest that plagued me in my pursuit. In 1925, I had given a lecture at Friends University in Wichita, Kansas, following which Dr. H. E. Crow of the biology department told of having been shown an "iron meteorite" some years before near Rosebud, Texas. It was said to weigh about 125 pounds and to be in the possession of a certain captain Jack Waters, a Civil War veteran. Professor Crow suggested that we might at some time be able to look into the matter.

My wife and I visited Rosebud, Texas, in November, 1925. We found the captain had died; but through his relatives and the local press we learned that the meteorite had been sent to the state university several years before. According to these informants the captain had requested its return, but the university reported that the stone had been lost.

Later that year we were in Austin and I visited the university. During a conversation with Dr. J. A. Udden of the bureau of economic geology he mentioned that the university had found one meteorite during his time there, and he showed me the Tulia stone which had been plowed up the year before. He said that he also had tested a small sample of a stone that was said to have come from Rosebud, but he seemed to know nothing of the mass from which it had been detached. The sample contained nickel, but he knew nothing as to the whereabouts of the parent stone. He had been told that it had been returned to the owner.

As I was leaving him Dr. Udden said he wished that I would go over to the geology building, on a different part of the campus, and look at a rock which he believed was in the office of Dr. Frederic W. Simonds, head of the department of geology. He said it was not considered to be a meteorite but that he, Dr. Udden, had some misgivings about the identification.

A day or so later I went to Dr. Simonds' office. No one was in the office but the door was open and I immediately saw a most beautiful meteorite lying in the far corner of the room under a long table. It was quite covered with dust but I could have little doubt as to its meteoritic character because of the abundant and wonderfully oriented pittings that covered the entire visible surface. I hurried out and down the hall in search of the professor. A short way down the hall I met a man who introduced himself as Professor Whitney. He informed me that Dr. Simonds was not on duty that morning but that he would be glad to help me as he was next in command. I repeated the request of Dr. Udden.

"Oh, yes, that stone! Well, come in, I'll be glad to show you."

As he dragged the stone out from under the table, he explained that someone had thought it might be a meteorite, but that the entire staff had held a consultation and decided it was just a basaltic boulder that had lain exposed on a hillside and had acquired those pits by sandblasting.

Dr. Whitney placed the specimen on the table and I began going over it with my ten-power pocket lens, almost bursting with excitement. My memory was parading before me all of the pictures I had studied of the various great meteorites, and this stone under my glass was certainly of first rank, if not the very finest specimen of all.

The professor leaned over my shoulder.

"Well, what do you think of it?"

"Dr. Whitney," I exclaimed, "it not merely is a meteorite; it probably is one of the finest specimens known!"

"You think so?"

"Yes, I'm sure, but I should like the opportunity to examine a bit of the interior."

"Well, I'll get you a sample," and with that he struck a shattering blow with a heavy hammer, sending chips flying about.

"Oh, please, don't mar the specimen," I cried. "It's too beautiful. I had in mind that it should be cut."

I picked up one chip about the size of my thumb and two or three smaller fragments. When I ground and polished them later, one of these smaller bits revealed beautiful chondrules and nickel-iron grains. Chondrules are small rounded bodies commonly found in stony meteorites. Another I dispatched to Dr. Merrill of the United States National Museum in Washington.

He sent a brief reply, "I find no evidence of meteoric origin," returning the specimen as I had requested.

At once I sent it again, begging him to grind and polish the inner face. A two-word reply came back: "Unquestionably meteoric."

My request for the privilege of describing this meteorite went unheeded, and when I returned to the university two years later I was refused permission to photograph it. Yet nothing seemed to have been done in the way of publication.

On my second visit I asked about the place of discovery of the beautiful meteorite, alias the sandblasted basaltic boulder. If Dr. Simonds remembered, he chose not to tell. He made an apparent effort to recall, then said, "possibly Glen Rose."

Thus, in 1933, when my first book about meteorites, *Our Stone-Pelted Planet,* was published, I listed the Texas stone as *Glen Rose,* for it still had not been officially described.

I did not know during my 1925 visit to the University of Texas that this fine specimen was the Rosebud meteorite that had been described to me in Kansas. I thought it might be, but that probably it was not, for Dr. Crow had spoken of an "iron," and Dr. Udden, when he mentioned examining a small sample of a stone from Rosebud, certainly gave no hint that it might have come from the mass he sent me to Dr. Simonds' office to see.

Up to this time I had accepted the report, relayed to me by the Waters family and the Rosebud editor, that the specimen taken to the university by the captain had been lost.

Having noted the seemingly total lack of scientific interest in the subject at the university, I continued to search for the Rosebud "iron." I corresponded with and visited relatives of Captain Waters in Alice, Texas. Hearing that I had offered in Rosebud to buy the specimen if it could be found, they joined other members of the family in a spirited search for it. The captain's relatives approached the geology department of the university in an attempt to recover "their specimen," but the university spokesmen, they reported, insisted that the captain's stone had been returned.

In any event, the Rosebud specimen was not described in the literature until fourteen years had passed since my identification of it as a meteorite. There was no mention of my name in the tardy description of this fine oriented stone which I had been first to recognize and which I had been denied permission later to photograph.

At that time, the middle twenties, all talk of rockets for exploration was regarded as the wildest of fiction, but I believed that man was destined to explore more and more of the universe by all possible means. Since meteorites constituted the only material source of information available, they must be the most important inorganic objects on this earth, fraught with information about the cosmos that could be obtained in no other way, and about the earth itself, which doubtless they had been bombarding throughout all geologic time. It seemed plain fact that meteorites could never become less important; certainly they must grow more so. Response to my lectures seemed to forecast a great increase in the number of collectors of meteorites among individuals as well as institutions.

There was just one jarring aspect of all my theorizing: Scientists themselves were remaining aloof from meteorites. Dr. Merrill's frank statement that there was not much more to be learned from meteorites apparently was dismaying only to me, his attitude being no surprise to anyone else.

No one seemed to share my view that any meteorite of any size must be more important than any other material on earth. Since my area of interest had no scientific standing there was only one way for me to go, and that was up. I was able to turn to my advantage this near-total disinterest that surrounded the subject of meteorites at the time my own fascination with it was becoming all-consuming.

I learned that less than ten per cent of the colleges and universities and practically none of the high schools and academies or small museums had a single specimen of meteorite, to say nothing of a collection. It was my opinion that meteorites were far more important than most minerals, fossils and other natural history specimens that were featured in those same institutions.

I also discovered what I considered to be a very short-sighted practice among the few museums, universities and colleges that had taken an interest in collecting and studying meteorites. In general, when the discovery of a new meteorite was announced each of these institutions would purchase a specimen from the mineral dealer who had acquired it or make an exchange for one if the new discovery had been purchased by an institution. If subsequently another individual meteorite turned up in the same general area and it resembled the previous find it was considered to belong to the same fall and was not in demand unless one of the few collecting institutions had failed to obtain a sample of the first one. And when a large number belonging to the same fall were found within a short time, there would be a ready market for them until each of the collectors was supplied, and then any remaining specimens would become a drug on the market.

I learned that quite a number of meteorites from the showers of Brenham, Ness County, Richardton and Canyon Diablo were still in the hands of farmers who had been unable to sell them. These persons would be glad to market stones that for them had only passing interest other than the money they could bring.

I visited some of the nearby localities of falls. I could have purchased, had I had the funds, several specimens of the Brenham pallasite from farmers who had found them years before. The same situation proved to be true with the Ness County meteorites. I was convinced that the same thing probably would apply to other falls which I had no opportunity to investigate.

Gradually, as I was able, I purchased those unwanted specimens that farmers had on hand. Before 1925 I acquired two Brenham pallasites of 117 pounds and 85 pounds respectively besides a number of smaller specimens. I obtained surplus meteorites also from the Ness County and Admire, Lyons County, Kansas, falls.

By this time my dream of an active science of meteorites included incorporation of specialized courses in all university curricula. I knew better than to publicize this whole dream; but I did do a lot of thinking and planning. For the present my job was to get set up so that the limited market for my lectures and specimens would support the beginnings of my program; then I would feel safe in resigning my position as teacher.

The harvest of Mexican meteorites constituted a good stock of marketable specimens, and a start in the right direction, but was not enough to warrant my resignation from McPherson.

Just before daylight February 17, 1930, the fall of a meteorite in the vicinity of Paragould, Arkansas, occasioned fear and wonderment. The press carried various announcements concerning the great fireball, which was visible over many thousands of square miles covering portions of several states. Though the spectacle occurred at an early morning hour when most people still were asleep—about 4:00 o'clock—the fireball's dazzling light and the accompanying detonations brought many persons from their beds. Testimony of a number of them that the ages-old expectation of mankind's demise by fire still was nourished in many minds.

A few hours after the heavenly display, Raymond Parkinson, a farmer who had been awakened by the light and the explosion, went into his field for his horses and came upon a freshly made hole. Investigation revealed an eighty-five pound fragment of stony meteorite lodged in the pit.

Parkinson sent me a sample, suggesting I might be interested in purchase of the stone. Since I had no Friday afternoon classes, Addie and I promptly arranged to leave the children with her sister next door and set out immediately on the 700-mile drive. Though roads were none too good, we took turns at the wheel, made only necessary station stops, lunched on the way and were at Paragould in twenty-four hours.

We found Parkinson in low spirits. He told us he had lent his meteorite for display in the high school, and that the school principal and science teacher had sold it for $300 to Stuart H. Perry of Adrian, Michigan, shipping it out by express in a typewriter case.

Making the best of a bad situation, we gathered all available data and visited the site of the find. Several of the many witnesses to this great heavenly event were very acute in their observations. There were discrepancies in these accounts as to the time between appearance of the great light and hearing of the detonations: as to whether there were one, two or three explosions; and as to the size, four, six, nine times the diameter of the moon. There was agreement that the light had gone out with the explosion and evident consensus as to the impressiveness of the experience.

One elderly gentleman who had gone out into the yard at 4:00 A.M., was standing where he had a clear view of the fireball passing behind the roof of the two-story house almost directly over his head. He pointed out its course with unusual exactness because he knew where he had expected it to hit the roof.

The hole from which Mr. Parkinson removed the eighty-five-pound stone was examined. It was on a slant of approximately 40° from vertical and its axis lay in an exact northeast-southwest direction. He had preserved the footwall of the hole which was slick from the plunge of the stone into muddy ground, because he thought it might be important.

There had been two small stones picked up in a small clearing in the nearby timber, one of which had made a vertical, cleancut hole about four inches deep, in the bottom of which the little stone was visible.

Using a map of the locality, I plotted the course of the meteorite, certain from the nature of the reports by witnesses that the eighty-five-pound specimen must be only part of a larger mass. I drew a line on the map, designating for search a strip not less than a mile wide and on a line from the Parkinson hole a distance of six or eight miles.

Because the unsurfaced rural roads had been rendered virtually impassable by heavy rains, and because I needed to return to my teaching, Addie and I went back to McPherson, again driving straight through and arriving in time for my Monday morning classes. Soon word came that an 800-pound stone had been recovered from a depth of eight feet just three miles from where Parkinson had found his stone, and right on the line I had drawn.

Before leaving Paragould I had engaged an attorney to purchase the Parkinson stone if and when it should be regained, and to act as my agent in the purchase of any other material that might be found. Now a long and nerve-wracking series of negotiations began. The owner was asking for bids on the stone and was receiving offers from another source. I wrote to officials of the institution which was bidding, informing them I had directed the search to the area where the meteorite had been found and that they were bidding on a meteorite for the recovery of which I had been largely responsible. The bidding ceased, but not before the price had gone to $3100, more than I could afford to pay and keep the specimen. I instructed my attorney to buy, realizing I would have to borrow to make the purchase and that I would have to sell the meteorite subsequently. I finally paid $3600 for the Paragould meteorite.

Two of my McPherson friends had come forward when the negotiations first began, each offering to lend me $1,000 without interest. The vice president of Citizens Bank informed me there was no need to bother my friends, that the bank would lend me the full amount. He handed me a blank note to sign and said that when I learned the exact amount needed I should wire the bank and the proper amount would be filled in. Meanwhile I was to write a check upon my personal account. The meteorite was placed on display in the bank's Main Street window until it was sold a few months later.

The 800-pound Paragould meteorite was found lying in a crater some eight feet wide and just a few inches more than eight feet deep. This hole was only about thirty feet from the pasture gate of a man named Fletcher, no more than 300 yards from his house. Fletcher had looked from his window at the time of the fall, while his frightened wife knelt praying. He knew of all the excitement of the farm and town folk. He must have known of the find of the Parkinson specimen. And yet, when he noticed the yawning hole by his gate, he blamed it on the digging of dogs. It was his neighbor, W. H. Hodges, who chanced to pass through Fletcher's gate and became curious about the big hole. He brought Fletcher to the scene and they took a slender pole and sank it through the water and mud in the hole and struck the hard mass of the meteorite in the depths.

Hodges, who lived three-eighths of a mile from the hole, described the fall and finding of the hole:

> Was going off the porch when light went out. Almost at once heard definite violent explosion from about 45° angle above and about 38° west of south from him.* Second detonation from 45° above horizon and slightly more east than north, perhaps two or three seconds after first. Was first man to find hole. Fixing fence and came to get a pole. A week before the pasture had been burnt off and revealed pile of clay thrown by meteorite—immediately thought it was a piece of the meteorite. Round hole eight feet in diameter, depth of eight inches from surface, was vertical, and loose dirt tapered to funnel from this eight-inch level. Held tub of water in bottom of funnel and bottom of hole of water was two feet below level of surface. Got Joe Fletcher

*Measurements were mine, made by having him sight on an instrument.

> and took slender stake, punched straight down from middle seven or eight feet, found nothing. Moved eighteen inches southwest and hit rock about eighteen or twenty inches down. Gobs of dirt thrown fifty yards all around hole, probably more south and southwest than in other directions. Nine feet to bottom of rock. Big bump end of rock against west of southwest wall. Shallowest rock lay about fifteen to twenty-four inches west of southwest of center of hole.

That same evening of the day Hodges found it, a small hole was dug down through the mud to the stone in the hole. The next morning the meteorite was taken out, requiring three hours of work by five men with a team.

While we were in Paragould making settlement for the big stone, Parkinson arrived in town. News of the generous price being paid was just more than he could bear. He strode resolutely to the high school and called on the principal, upon whom he placed blame for the loss of his meteorite, led him into the school yard and administered physical retribution. Then he marched his man to the police station, told his story, paid a $2.50 fine to sympathetic authorities and sent the educator back to his school. Parkinson ultimately was awarded the $300 that had been paid for his meteorite.

The Paragould meteorite was the largest known to have been seen to fall up to that time, and also then was the largest known intact stony meteorite in the world.

Many years after the Paragould fall, I was told a tale about Paragould that is an example of the way the accounts of meteorites, particularly relative to their size and to the size of prices paid for them, sometimes become distorted. The fellow recounted that he had seen the fall of the Paragould meteorite, and that the stone was so hot it couldn't be touched for two weeks. The fall had "lighted up the whole place like daylight," he reported. He described the meteorite as weighing a hundred tons. "Big as half a room." The buyer, he said, had resold the meteorite for $400,000.

The actual dimensions of the Paragould meteorite are twenty-nine by twenty-eight by twenty-seven inches. And the price I received for it was $6,200.

The Paragould meteorite had profound effects on our lives. I have never ceased to regret parting with it, but I had paid a price too high, and was forced to give up either the specimen or my dream of making meteorites a new vocation. And Paragould, with the $2,000 profit it brought, was the way to my dream.

Addie and I were feeling our oats. In two months we had been reimbursed for all our time and effort, with profit besides. Neither of us could think that it might be many years before such another windfall. I had been waiting for money enough to finance a changeover from a steady, salaried job to an endeavor both irregular and unpredictable in nature. Now, on the strength of Paragould and the stock of meteorites I had built up, we seemed near enough to solvency for me to dare resign my teaching position.

I felt dissatisfaction with the situation in which I found myself, giving half of my time to the job I was being paid to perform and the other half to an idea apart from it. I was anxious to go new ways. I wrote out my resignation. We would sever the umbilical cord of salary. From this time on, meteorites would be my career. At this moment I held no professorship, no institutional connection, no visible means of support other than an *idea.*

I could not expect that meteorites promised an easy living, but what I wanted was a career that would be interesting; would make possible the adding of some bit, small or great, to the fund of human knowledge, and at the same time would contribute to the pleasure and interest of living for many people.

"Do something that needs doing," I had often told my students, pointing out the yawning breaches in man's knowledge of zoology, botany, bacteriology, entomology, geology, astronomy. And I had been attracted to so many of these gaps that my difficulty had always been the selection of one to the exclusion of others, aware that knowledge of these various fields had already grown so extensive that one must specialize in order to be able to add anything of importance. For teachers, which most of my students aspired to become, there was always the opportunity to help others by opening their eyes to the beauty, immensity and complexity of the world about them. But for myself, I felt that I had found a new field, where I could both widen the vision of many persons and at the same time contribute to the sum total of human knowledge.

Newton had given us a world of order for one of chaos; Copernicus and Galileo had provided a solar system in trade for the old geocentric universe; Darwin had substituted an evolving world of life for a static one; Hubble had given us our multi-galactic universe for the solar one. And now, we were in the process of discovering our planet to be a youthful growing orb, playing hide-and-seek with a multitude of attacking asteroids endeavoring to knock it off its axis. There indeed must be more things in heaven and earth than were dreamed of in our philosophy and, surely, meteorites must offer something to our world store of knowledge.

*Don't keep forever on the public road,*
*going only where others have gone and*
*following one after the other like a flock of*
*sheep. Leave the beaten track occasionally*
*and drive into the woods. Every time you*
*do so you will be certain to find something*
*that you have never seen before.*
*Alexander Graham Bell*

# 4. PEAKS AND VALLEYS

It is doubtful that any of our friends or relatives looked upon our 1930 move to Denver with sentiments other than pity.

Our total assets were a 1929 Chevrolet and about $2,000 in cash, which would dwindle considerably by the time we were settled. We had a verbal agreement with Ward's Natural Science Establishment, Rochester, New York, to buy our spare meteorites up to $4,000 a year.

We loaded our household goods into the back of the farm truck of a brother-in-law of Addie's and headed for Colorado. In late October, 1930, we moved into a row house near downtown Denver. Our children's ages were 11, 8, and 5 years.

When I had turned in my resignation in the spring only the last session of the Rocky Mountain Summer School where I had taught summers since 1922 remained before severing all ties with McPherson College in McPherson, Kansas where I had studied as an undergraduate and had then taught for ten years. We were prepared for the cut-off of all visible income other than sales of meteorite specimens and lecture fees. An unexpected stroke of good fortune was an opportunity to join the staff of the Colorado Museum of Natural History (now the Denver Museum of Natural History) as curator. We would, after all, have a regular income—an honorarium of $50 a month under an arrangement requiring only that my collection be placed on exhibit and that I make my headquarters in the museum.

We set up a meteorite cutting laboratory in Palmer Lake, Colorado, about forty miles south of Denver, in the little general store run by Ray Niswanger, a close friend during the nine years of operation of the Summer School and a leader in the community. He had suggested that we set up a shop in an empty room of.his store, having heard me say that I needed a saw to meet orders of collectors. Winters at Palmer Lake's altitude of 7,280 were long and severe, and he assured me the work would help fill empty hours.

*__Nothing__ in the world can take the place of persistence. Talent will not: __nothing__ is more common than unsuccessful men with talent. Genius will not: unrewarded genius is almost a proverb. Education will not: the world is full of educated derelicts. Persistence and determination alone are omnipotent. The slogan "Press on" has solved and always will solve the problems of the human race.*

*—Calvin Coolidge*

# 5. ON VARIOUS TRAILS

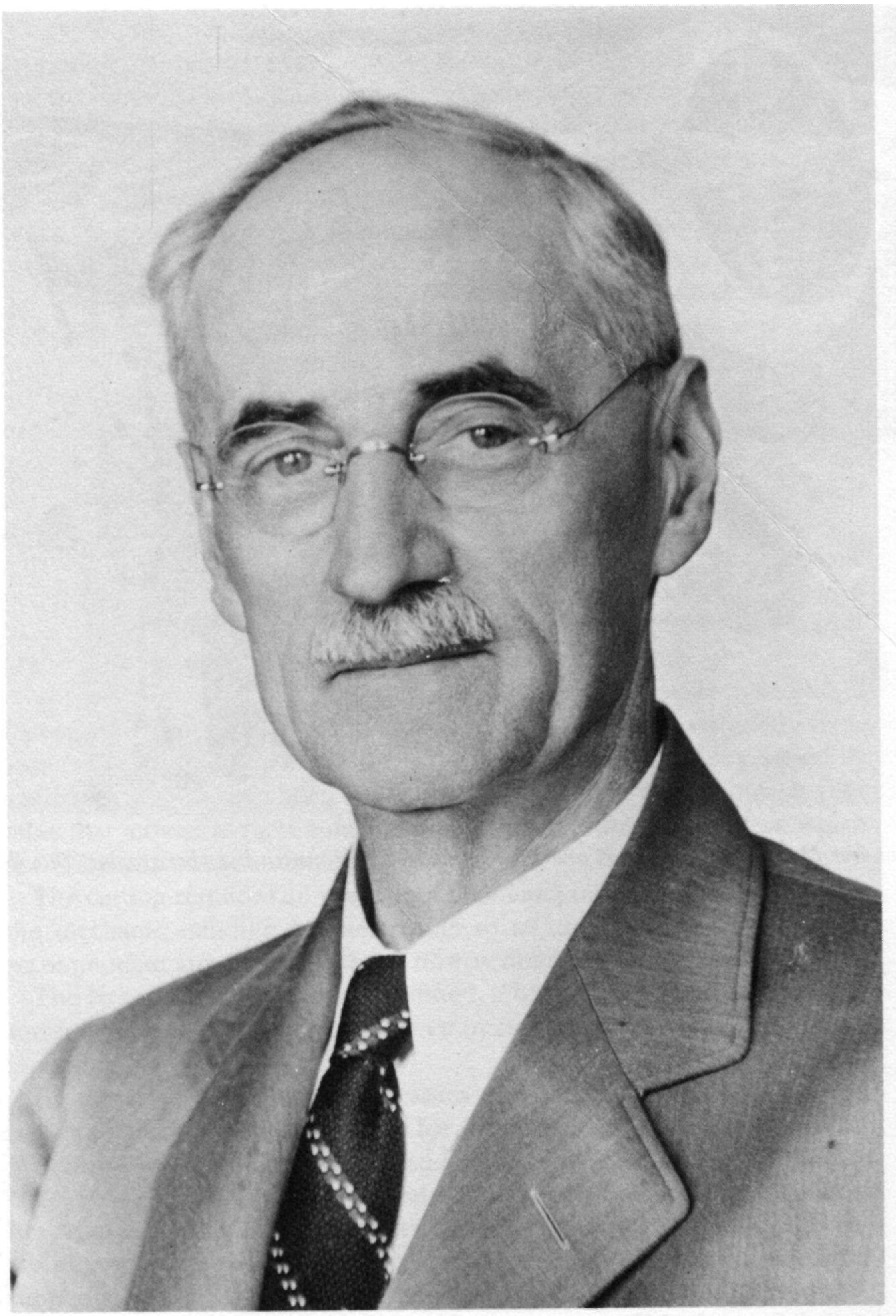
In Santa Fe, New Mexico, while on a truck delivery during the spring of 1932, I stopped for a brief visit to the anthropological museum there, intending to inquire about a small meteorite that recently had been found in a pottery vessel in an ancient ruin. I parked my truck in the lot and went in.

As I was passing among the exhibits, quite unexpectedly I met Dr. Alexander Wetmore, director of the United States National Museum, who happened to be in Santa Fe on a one-day visit. On a bench outside the building Dr. Wetmore and I sat and visited, turning our talk to meteorites. When he asked how our work was going, I grinned and waved at my truck parked nearby. On the spot he offered a tentative arrangement for some field work the following summer in the northwest part of the country on behalf of the National Museum.

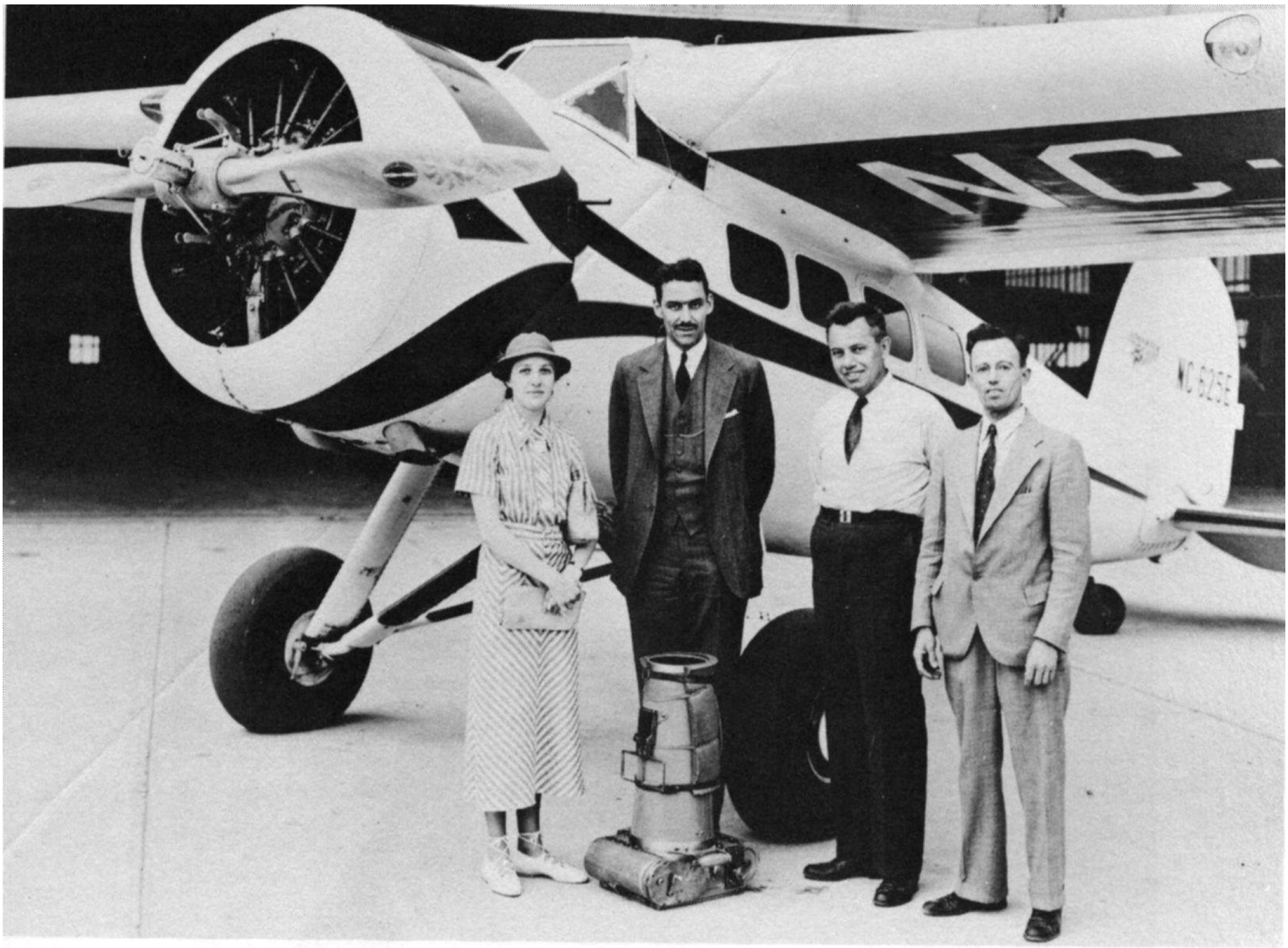
We made vacation arrangements for the children, and Addie and I undertook several projects, including an investigation into the Port Orford, Oregon, meteorite story.

The Port Orford case is an enigma. This famous pallasite has never been rediscovered since it was seen first in 1859 by Dr. John Evans, a government geologist, who reported that he detached a small sample from a parent mass estimated at 22,000 pounds, but died before actually mapping the site. We, like other searchers, found no trace of it.

Some scientists became convinced the great mass never existed, that the sample collected represented only a small mass and that Dr. Evans had become confused in his memory as to where he had obtained it. To me it appears unlikely that a geologist could detach a piece of pallasite from any parent mass without holding in his mind a very reliable picture of the source of the fragment. Field experience has prepared me to understand just how plausible it is that such a great meteorite could exist, just as described, and yet remain unfound. Indeed, I should be greatly surprised if it is ever rediscovered though I feel very sure it exists.



*J. D. Figgins, Director, Denver Museum of Natural History.*




*Flight over Meteor Crater. Herbert and Page Fales. H. H. Nininger and photographer, Otto Rouch.*

Ray volunteered to run the saw for a very nominal charge per hour, proposing that payment for his work should be postponed "until you can pay me out of the income from the business beyond your living expenses."

Ours was the first commercial cutting laboratory for meteorites in the United States. The only other such equipment in this country was that at the United States National Museum. Often we obtained new specimens as payment in trade for the cutting. Slices of meteorites cut in our laboratory went to every great museum in the world.

To cut these exceedingly tough hunks of metal we used an abrasive saw, a band of soft steel without teeth, run on a regular bandsaw frame such as is used in a carpenter shop, but operated at a much slower speed.

The bands of soft steel were made to order. They were two or three inches wide and were used until they were worn down to a width of about an inch. As the band revolved, a trickle of water carrying carborundum, the cutting agent, was directed against the biting edge where it entered the meteorite, mounted firmly on the saw table.

It was intriguing to watch that smooth, harmless looking band eat away at a stubborn iron meteorite. The piece would be imbedded in plaster of paris to steady it on the saw table, and there it would rest for hour after hour or day after day, while the saw slowly gnawed through it.

The saw stood taller than a man, the band measuring eighteen and a half feet and running on two thirty-six-inch wheels. It had one stationary table on which was mounted a track which carried a movable table operated by a screw with sprocket wheel. On this moving platform was another smaller table that moved at right angles to the larger movable one and on which the meteorites were mounted in plaster.

The cutting required an average of about an hour per square inch, with the mechanic standing by meanwhile to adjust speed and pressure to accommodate any unusually hard obstructions encountered.

The largest slice we cut and exhibited, a beautiful nickel-iron that measured seventeen and a half by thirteen inches, required about nine weeks of sawing.

By the close of the summer session of 1930 the lab for cutting and polishing had been set up and paid for, and we began cutting the Mexican meteorites at once. The saw ran steadily in Ray's little store in Palmer Lake, providing specimens that sold readily. Soon I had two new meteorites from Nebraska and one from Colorado. Ward's Natural Science Establishment was selling my material on consignment about as fast as I could supply it. Things in Denver seemed to have started off in our favor.

Alex Richards and I had been deep in the interior of Mexico in October, 1929, when news was flashed of the greatest stock market crash in history. When Alex mentioned the headlines I remember thinking, "That will not affect me." To me it had seemed that since I never had dabbled in stock buying I would not be injured, a measure of how little attention I ever had directed to the financial structure of our country. I was so immersed in meteorites that I paid little heed to talk of depression. The disastrous effects of the financial crash did not reach the western states to any noticeable extent until early in 1931. By then I had given up my $2,200 salary and the annual summer school income of about $1,000.

In the fall of 1931 Addie and the children and I moved into a middle-aged two-story house close to the park and museum, undertaking a mortgage on the strength of our agreement with Ward's and stubborn optimism that the depression wouldn't reach us.

Ten years before when I was thirty-four doctors had told me my heart was disabled and had ordered an existence of relative inactivity—no stair climbing, no bicycling, no volley ball or tennis, no mountain climbing, no high altitudes, no this and no that. Now I had survived ten of those "careful" years, which had featured three long trips and some rather strenuous activities, and I scuttled some of my caution by adopting a bicycle for my habitual transportation to the museum, about a mile from home.

But the depression was indeed going to affect us. The purchase agreement with Ward's, our only real "cushion" of income, was terminated after about a year. The dealer could no longer accept our specimens, for no one could buy them. Our situation was precarious.

When our agreement with Ward's was canceled, I made direct contact with those institutions that had collections of meteorites and offered such specimens as I could at special prices. Results were encouraging but by no means sufficient. These direct dealings with institutions and private collectors fell off more slowly, but nevertheless the shrinkage was sorely felt.

As the sales of specimens slowed down I began to offer my lectures more and more to colleges, universities, museums and scientific organizations which still had lecture funds.

When our financial plight had about reached bottom I received an invitation to lecture before the Cosmos Club in Washington, D.C. The results of this lecture were most heartening. At the close of the meeting a committee was called together by the Director of the United States National Museum to consider what could be done to promote my work, and the result was an agreement on the part of the Smithsonian to purchase $2,000 worth of meteorites or more each year if I could furnish them at prices comparable to those charged for meteorites by regular dealers. This seemed to place a floor under our feet and I returned home with renewed assurance.

We had not enjoyed this feeling of security long before a change in personnel in the National Museum wrecked the plan, for after I had planned a field program sufficient to assure that I could fill the orders the new curator wrote informing me that the museum simply could not buy meteorites as had been promised because all of the allotment had been spent for minerals.

About this time I was offered a university position that involved teaching almost entirely. I reasoned that acceptance would put an end to my investigations. Turning down the offer, with economic conditions as they were, was a good deal like refusing a life line while aboard a drifting raft, but my life objective had become so fixed that I made the rejection without a qualm and returned to the daily struggle that was required by my chosen work. I felt that such a teaching commitment would kill my field program, because classes would take up so much of my time that very little if any field work could be accomplished. I chose to continue the risks of making my program self-supporting.

Even in McPherson the problem of financing an expensive hobby had made our mode of living somewhat more austere than that of the average professor's family. After I left the college it was evident that our growing collection of meteorites would absorb our entire effort and would constitute our entire estate. When the depression years reduced our market possibilities, we gave up owning a house and moved into a rental house. We borrowed to the limit on life insurance policies. There were periods when the purchase of a pair of children's shoes was an occasion for a family conference, and when the replacement of Dad's suit was solved via patches on the old one. The menu was dictated by economy rather than taste.

If there ever was a month during that time of our children's growth to adulthood when payment of our bills did not demand the best that was in us, Addie and I never have been able to recall it. What we managed to do was to tie together our working arrangement with the museum, cutting and polishing operations, the lecture schedules and investigative trips with just enough in sales of specimens and fees from lectures to finance another trip, to permit scheduling more speeches, to recover some new specimen to cut and sell.

As the nation sank deeper and deeper into the trough of the depression there was less and less money for either lectures or specimens, but even during the worst years there remained a few good customers. Teachers still were being paid and some who had heard my lectures became determined to acquire a meteorite specimen or even a small collection. Some institutions could purchase meteorites for their departments of geology, astronomy or earth sciences. Museum curators and even a few businessmen were among our customers.

We functioned first as *The Nininger Laboratory,* and in 1937 took the name *The American Meteorite Laboratory.*

My curatorship at the museum gave me a base of operations. There was an understanding that mutual arrangements could be made for the museum to participate in field projects from time to time on a fifty-fifty basis, but there was no obligation on either party to accept such a cooperative proposal. Our contract consisted of an exchange of letters and verbal understandings. The arrangement lasted fifteen years and ended amicably. During those years my field program brought to light nearly 200 meteorite falls, aggregating about 1,500 meteorites, not counting several thousand from each of several craters.

There were long periods when all visible evidence spelled failure. There were many times when the larder approached emptiness, and the bottom of the barrel was scraped so often that we could almost see through it. It was a very difficult thing to make a living for a family and at the same time hold on to my objective of seeing a science of meteoritics developed, with a companion dream of sponsorship by an institute of meteoritical research. Our practice was never to part with the bulk of a new meteorite. We would remove one or more slices and let them go to the few institutions and collectors who furnished a ready market, then store the remainder.

The collection seemed to grow with amazing rapidity. The cataloging alone was a large chore, and correspondence was heavy. Addie, near the beginning, decided to handle the office detail involved with our meteorite search. Certainly there was no money for secretarial help.

The whole family cooperated. The children did not demand luxury; no good would have been served to ask. Our one luxury was a good car, a serviceable one to carry the load of our field work.

Asked how we managed to finance our program, my usual answer was to the effect that I hardly knew myself how we did it. We always seemed so busy doing it that we never could find time to figure out how it was being done. We never stopped to worry about the over-all problem of finance. We simply solved the immediate problems month by month, kept our credit good at the bank, paid off notes, signed new notes, worked harder and went ahead.

Always in the background of our thinking was the realization that we were steadily amassing a stock of meteorites which, if worse came to worst, we could depend on to see us through. I knew that the value of meteorites had through a hundred years proven far more stable than any currency or coin of the realm. Their status was something like that of diamonds—they were virtually indestructible, with proper care, and of everlasting value, despite the fact that for many years interest in them had faded. I held to the belief that man's next step in exploration would be into space. Certainly material from space must carry a premium.

At about the time the Smithsonian cut off the short-lived arrangement to buy specimens from us in some quantity, thus just about sinking our little boat, rescue came our way in the guise of a man and a White truck.

The house into which we first moved in Denver was only a few blocks away from Dean Gillespie's White Truck distributing agency for the Southwest.

Dean M. Gillespie later served a term in Congress, and his business enterprises eventually reached into other fields, but when I knew him first he was guiding his truck agency through the hazards of the depression.

Dean was the one man who most consistently offered me a way through financial thickets during the years from 1931 to 1946.1 met him soon after we moved to Denver, having been told by a mutual friend that Dean was an amateur meteorite collector. After hunting up his office I walked in, gestured toward a big meteorite lying on his desk, said I guessed this must be the place I was looking for and gave my name.

Gillespie leaped to his feet.

"We are two people of the same mind," he told me, and went on to describe his interest and his specimens.

On better acquaintance, having learned I operated habitually on a shoestring, he made a proposal that proved to be of mutual benefit and that served to keep me going financially in a number of instances over a period of some ten years.

Addie and I never knew when a fireball would appear that we would wish to chase down, or when we might hear of a meteorite somewhere that called for a trip of investigation and possible purchase, and of course we were nearly always broke.

When such occasions arose and I was short of cash, Dean would advance me money enough to make the trip, our agreement being that if the effort were successful, we would divide—but if nothing came of it, I had simply lost my time, and Dean had lost his money. Sometimes, if a project offered slender promise of returns, I would guarantee its cost by supplying meteorites already in my possession.

Dean helped me additionally, in an unusual way. One day, he called me into his office.

"Can you drive a truck?"

"I never did," I answered, "but I suppose I could."

Dean explained to me that he thought he could help me out. As a distributor he had trucks driven into Denver from the factory in Cleveland, Ohio, and he also delivered trucks to various localities in the West.

"My drivers get four dollars a day and expenses," Dean told me. "I'll pay you the same. If you want to stop on the way and get some work done for yourself you can do that on your own time and expense."

So I became a part-time truck driver. Some of the lecture appointments I kept during those years were reached by truck transport. When I attained my destination I spruced up, changed my clothes and headed for the auditorium. After my lecture and a night's sleep, I would return to my truck and the road, my suitcase in the cab behind me. So far as I am aware neither my audiences nor the arrangements committees ever suspected their speaker had come from truck cab to lectern. I was not proud, but I respected institutional sensitivities.

This system allowed me to visit museums and study collections en route, to make meteorite exchanges with various collectors and on several occasions made possible the recovery of new meteorites.

The bulk of our collection, except for specimens on exhibit in the museum, was carefully labeled and stored in a fire-proof walk-in vault in the basement of Dean Gillespie's business building. Dean never used this vault. The fact that I held the only key created a small friction. Our meteorite saw had been moved to my working quarters in the museum in Denver after two or three years in Palmer Lake; when museum space became cramped Dean made a place for it in the basement, where it remained in use until interruption by World War II. Dean enjoyed showing off my meteorites, or my cutting work on the great circular saw, or my fund of knowledge, to his friends and business visitors. He liked to be able to take his customers into the vault. Dean was a businessman through and through. He found that by getting me to talk to his customers, stirring their interest in something else, they could often be softened up for a successful truck sales pitch. The only areas of disagreement Dean and I had were the matter of the storeroom and use of me as window trim. He was strong-minded when it came to running his business, but so was I where mine was concerned.

Our joint ventures for the most part worked very well. Frequently I would go to his office, sign a note for two, three or five hundred dollars, climb into my car and take off on some project or other. Sometimes I'd come back with a good find, sometimes return empty-handed.

Our accomplishments over the years that were so critical financially could not have been possible if Dean Gillespie had not been there to call upon for a few hundred dollars when a loan was needed. He always stood firmly on business principles. He demanded and received his full share when a venture proved fruitful, but when a venture failed to yield he was a good loser.

Dean recognized the importance of meteoritical research. At the time of his death in 1949 the Gillespie collection was one of the few really large private collections in existence.

After delivering a truck to El Paso, Texas in 1931,1 gambled some time and money on a flight to Chihuahua City, Mexico, seeking the "long-lost" Huizopa meteorite. This fall had been described in 1907 as "four irons" on exhibition in Chihuahua City, but since that time the largest mass, weighing 258 pounds, had been lost from sight and record. I had sectioned and studied one of the smaller masses where it was preserved in the *Institute Geologia* during my earlier trip to Mexico City, and I recalled the state of confusion and abundant mislabelings that typified that institution's collection at that time. Weighing the circumstances of the disappearance I reasoned it was worth while to make a search.

In Chihuahua City I had little trouble finding the *Museo Historia Natural del Estado Chihuahua."* It was within sight of the Hotel Palacio, and the sign read just as I had seen it worded in the British Museum *Catalogue of*

*Meteorites.* The door stood open and a few steps back from it sat a woman doing needle work who evidently was in charge of the place. Immediately inside the door stood a tall, narrow pyramid of shelves, loaded with choice, colorful mineral specimens, its base piled about with huge chunks of different ores from the various mines of this rich mining state. As I stepped on the threshold I saw the blunt end of a large iron meteorite projecting from the pile of ore specimens.

After moving the ore, I was certain that this was a specimen of the same fall I had examined in Mexico City. The custodian permitted measuring, weighing and photographing of the meteorite, and said that the Museum belonged to *El Governador.*

From the lobby of the hotel I called the United States consul and he agreed to assist me. The governor was out of town, not to be back until *manana.* The next day the reply was the same, and the next, and so for a week. Meanwhile, however, I was proceeding on my own, conferring with the consul and going about the city in search for a proper container for the meteorite. Wooden boxes suitable to such a purpose were almost unknown in Mexico.

Finally, the governor, Sefior I. Andres Ortiz, returned. A crowd of citizens awaited him in the anteroom of his office. The consul interpreted my plan. Recognizing the mutual advantage of having the meteorite studied properly and labeled correctly, the governor promptly authorized me to take the meteorite to Denver, cut it in half, return one half, properly polished, etched and labeled, to the Chihuahua Museum, and retain the othe** half for this service.

From my half of the Huizopa meteorite I cut several slices for museums whose budget had not felt the depression too deeply, at prices that definitely bolstered our frail budget. During the course of the year following its acquisition, the Huizopa meteorite brought in a couple of thousand dollars, a considerable return for my personal investment and far beyond the wages of my truck assignment.

2

On the afternoon of May 10, 1931, W. H. Foster was hoeing in his garden at Eaton, Colorado, when he was attracted by a humming sound, not unlike that of a stray bullet, which seemed to come from the northern sky. A half-minute or so later the sound seemed louder, as if approaching him. Foster leaned on his hoe handle and listened; this seemed a long time for a bullet to whine. He scanned the sky but saw nothing.

As the noise grew louder he feared being hit and took a step backward. He felt the air blast in his face as an object whizzed past and struck with a thud about seven feet south and a little west of where he stood. Looking down he saw where the sun-baked crust of the soil had been broken up, and projecting from the moist dirt thus exposed was a small, bright bit of metal.

Foster pondered for a moment, then stooped to pick up the object, "burning" his fingers, he said later, as he did so.* Puzzled, he walked across the street to show it to John C. Casey, the high school superintendent. Casey was as much puzzled as Foster, and called in the science teacher, Glen Mills. The janitor came also. But none had an answer. This was no bullet, but neither did it resemble the meteorites on display in the museum in Denver. Mills was quite sure he never had heard of a copper meteorite, and the nugget looked more like molten copper than anything else.

Could it be a burned-out bearing of an airplane? None had heard a plane that morning, nor had Foster seen any as he scanned the sky seeking the source of the strange, whizzing sound. There was not often a plane in the air over the village of Eaton in the year 1931.

The matter remained an unsolved mystery. No publicity was given it. But Mills, the science teacher, was not satisfied. Three weeks after the event he attended a science meeting at which I was present also and described the happening to me, requesting me to investigate Foster's coppery nugget.

I called on Mr. Foster, accompanied on the visit by J. D. Figgins, Director of the Colorado Museum of Natural History, and Frank Howland, mineralogist, and H. C. Markman, geologist, both of the museum staff.

Foster was cordial and cooperative. He showed us the specimen and told us the same story he had recited to Casey the day of the fall. The possibility that the thing was a meteorite had been suggested to him; he had no idea of his own what it might be. We all agreed the object differed notably from any known meteorite and, though none of us could offer any other explanation of the occurrence, it could not be considered a meteorite on the basis of the accepted criteria by which meteorites are recognized.

But I could not be satisfied to leave the matter there. An intensive study of the surface features of meteorites had convinced me these markings constitute one of the very best identifying characteristics of meteorites. When I had examined the coppery nugget under my ten-power lens the surface was shown to be pitted in a manner that was unknown to me in any metallic object other than a meteorite.

Since the first recognition of meteorites by science in 1803 there had been seen to fall a new variety of meteorite on an average of every

***The usual report by persons who have picked up meteorites soon after fall is that they are "cold." There have been a few reports that metallic meteorites have been "too hot to hold," and one lad described a newly fallen iron as "too cold to touch." Meteorites have been known to fall into haystacks without igniting them. The good heat conductivity of copper could explain the warm condition of the specimen reported by Foster.**

twenty-two months. Several of these varieties still were known by only a single fall. Could not this also be a "new" type of meteorite?

Mr. Foster loaned the specimen to me for further study and later permitted me to purchase it for the nominal sum of $5. Never did Mr. Foster seek any publicity, either at the time of the fall or afterward. For ten years I withheld any published statement. During this period I studied the specimen from time to time and had a partial chemical analysis made of it. I could find no flaw in Foster's story and could not think of any other plausible explanation of the nugget's arrival, but I held up final decision that it was meteoritic in the belief that sooner or later there must come some corroborative evidence.

On February 13, 1939, a nephew of Addie's, James Harold Rothrock, who lived in our home for some time and who was an able helper to me in shop and field, was breaking in a new employe, Mr. Hummiston, in the grinding and polishing laboratory, where several slices of the Garnett stony meteorite were being ground and polished. As the two men worked on the revolving grinding table, Harold was amazed to see a grain of metallic copper that had been exposed by Hummiston's grinding. Realizing that this was very unusual, Harold laid the slice aside. Hummiston said the grain of copper had been considerably larger when he first noticed it.

This beautiful little grain of copper, embedded alongside a small sulphide inclusion, provided some of the corroborative evidence I had been awaiting. Location of the bit of copper three centimeters below the original surface of the stone ruled out any chance of entrance from surrounding soil. The meteorite had been found in a location far removed from any copper deposit. The United States Museum verified that the grain was copper.

In the Estherville, Iowa, shower of May 10, 1879, there was precedent to hypothesize that the presence of metallic particles could mean that metallic masses of larger size might once have been imbedded in stony matrices. In the Estherville case a large meteorite of probably hundreds of tons was composed primarily of brittle stony matter with blobs of embedded metal. The stratospheric break-up which occurs to most, if not all, stony meteorites reduced the brittle matrix to dust, and a tell-tale dust cloud of tremendous size remained aloft for hours, while the more resistant metallic inclusions, set free by the shattering, traveled to earth as individual pellets. In its form and surface markings the Eaton specimen fitted such a history as that of the pellets of the Estherville fall.

When I published my findings in May of 1943 in *Popular Astronomy,* there was a cry of "Hoax!" to which my answers were that Foster was of unimpeachable character, he lacked facilities for producing such an object and, above all, he sought no publicity nor profit from the eipsode; also, that if another party were deemed to be the perpetrator of the hoax, there was no evidence as to how such an act might have been accomplished.

By careful questioning and by re-enactment of the scene, it was evident that Mr. Foster had heard the whining noise of the "bullet" for a minute or two minutes before its landing. From what is known of the terminal velocities of such small objects, we may assume that it traveled not faster than 300 to 500 feet per second. Allowing an average speed of 400 feet per second for a period of 90 seconds, it must have traveled 6.8 miles after he first heard it and must have been traveling at least 40 seconds before the sound first reached him. If we allow a speed of a mere 280 feet per second for those first forty seconds, then the object must have started on its whining course ten miles from the Foster garden. Certainly no individual nor known terrestrial force could have put this object into a trajectory at a height of ten miles or so and kept it whining audibly for ninety seconds.

The production of an article resembling the Eaton meteorite would be quite simple chemically. But the faking of flight markings—the peculiar pittings and flowings of metal produced by the passage of a meteorite through the atmosphere—would be a different matter.

Other nearly nickel-free meteorites have been seen to fall, and had they not been witnessed would almost certainly have not been recognized as meteorites since they did not fit the accepted pattern. In 1915 Farrington listed four meteorites in which nickel, the identifying metal of meteorites, had not been found. Both the Norton, Kansas, and Pena Blanca Springs, Texas, meteorites are so relatively nickel-free that ten- or twenty-gram random samples might show none at all.

I think that meteoritic origin for the Eaton nugget cannot be ruled out on the basis of its content of small amounts of copper, lead and zinc, roughly the formula of artificial brass, for these three metals also are sometimes found associated naturally in the rocks of the earth. It is true that in earth rocks they are chemically tied up with oxygen, sulphur and other minerals, but the same thing may be said of terrestrial iron and nickel, while the unadulterated metals are found in meteorites.

As of noon, February 18, 1948, meteorites of the Cumberland Falls, Kentucky, and Pena Blanca Springs type were so rare that only about 200 pounds had been recovered in nearly one and one-half centuries. Then, five hours later, more than a ton of such material had planted itself in the fields of Norton County, Kansas, and Furnas County, Nebraska, thus in one afternoon quantitatively revolutionizing the "over-all composition" of recovered stony meteorites. The Eaton specimen remains unique, but a single fall could place it among the most common of meteoritic types.

The line is thin sometimes between authenticity and honest but mistaken reporting.

The Eaton case is typical of situations where the judgment and acuteness of observation of the witness is crucial. Did the witness see what he believed he saw? Did he pick up the object that fell, or an object occupying the space where he believed he saw something fall? Were the thing he heard and the thing he picked up one and the same?

Sometime, perhaps, complete chemical analysis, or the new spectroscopic, isotopic tests that measure exposure to cosmic bombardment, or a new, verified, witnessed fall of a copper meteorite, will provide a final determination of the origin of the Eaton specimen.

In the summer of 1931 Addie and I traveled with the family through the broad wheat fields of Saskatchewan on our way to visit my sister and her family in a northern settlement of that Canadian province.

There was little vegetation other than wheat and there were quite a few rock piles tossed up along the fences. This seemed a likely area for meteorites. I stopped at the offices of the *Saskatoon Star* to request that a news story be run that might alert interest and result in a find.

The editor of the *Star* suggested that I write the piece myself. I addressed farmers suggesting they might very well have hauled meteorites along with the country rock dumped beside their fences. I explained how to recognize meteorites, stressed the importance of recovering these stones from the sky, and, as always, directed that they chip off but a small corner of any likely specimen, thus avoiding damage to the whole.

A few weeks after we had returned to Denver our mail brought a sample, weighing about an ounce, and plainly meteoritic, from a farmer near Springwater, Saskatchewan. The finder wrote that he had found the parent mass, weighing about forty-four pounds, many years before, and that he had sent a sample at that time to the provincial assayer, who had reported that the piece appeared to be artificial iron that probably had leaked out of a furnace. The assayer added that the thing had no value.

I requested the farmer, a Mr. Ward, to send me the main mass, which he did. When he received my check in return he wrote that he had found more of the meteorite, and he kept on searching until he had found about a dozen individuals weighing about 200 pounds total.

Some months later another sample arrived from Saskatchewan, a tiny bit of meteorite, only the size of a grain of corn, sent in by Mr. A. D. Ebner, a farmer near Bruno.

Ebner reported that he had been hauling rocks from his field and when he started to put one chunk into his stone-boat he found it was so heavy it required both hands to lift it. He gave it a second look, remembered the article in the newspaper and decided to send in a sample.

The Bruno specimen proved to be a very well preserved, beautifully oriented meteorite, one of the finest examples of metallic meteorites known, so unusual that its picture has been carried in many publications. Only the one piece ever was found. Mr. Ebner had treated it with great care. Had he acted with the roughness and disregard with which many meteorites have been treated, hammering and chiseling or sawing, much of the value of the beautiful Bruno meteorite would have been lost.

With the hope of obtaining more of the Springwater fall and with the thought that there might be a recognizable crater associated with it, Addie and I went again to Saskatchewan in 1950.

In our 1931 correspondence with Mr. Ward, he had told us a really tantalizing story of the "big one that got away." Before he had learned the true value of the heavy dark rocks he had thrown away the largest one he ever found.

"We were filling up a well about seventy or eighty feet deep," he related. "I was hauling rocks to fill it up, and this particular rock was so heavy we used a team to pull it onto the stone-boat, and then when I got to the well it was all I could do to dump it. I tore my hands on it rolling it into the well."

When we called at the old Ward farm in 1950, we found it being operated by a Mr. Staples, who took us out to search for the old well, but it had been filled in very efficiently and the field had been cultivated over it for thirty years; we couldn't tell exactly where it was.

This situation called for a detecting instrument. There are two kinds: mine detectors and magnetometers. A mine detector is a device developed by the army for the purpose of detecting explosive mines and "booby traps." The device was long used by treasure hunters and since the mid-30's by meteoriticists in a search for buried meteorites. It is an electromagnetic device, often described as a magnetic balance which gives a signal to its operator when passed over a metallic object. It is used only after a location has been made by a find.

A magnetometer is a very delicate device for measuring the earth's magnetic field, used for detecting ore bodies and by geophysicists to detect anomalies in the earth's gravitational or magnetic field. Obviously it can also be used to locate buried meteorites, after one has determined that a fall has occurred in a given area by the accidental discovery of one or more specimens.

We went over the area with a detecting instrument in case the meteorite was in the top part of the fill, but we had no luck. Then we decided to go over the rest of the field with the instrument, and here we met a problem. I hadn't gone fifty steps until my earphone gave a beautiful bark, and we began to dig frantically. We dug down a couple of feet and brought out a beautiful granite boulder.

"Granite shouldn't give out a sound like that," I protested, but I passed the instrument over it and got the same bark. Examining the granite closely we saw that it seemed to have little particles of magnetite; I learned later that this is a very common constituent of certain granites. In that glacial region they seemed to have every kind of granite—white granite, pink granite, blue granite, gray granite, black and brown granite. As we went about the field we dug up about fifty granite boulders. One variety —not the blackest nor the heaviest—would sound persistently in the earphones just like a meteorite.

As a substitute for exploring with the detector, we decided to scout the pastures still free of cultivation in hope of finding a mass still projecting from the ground, or perhaps a depression that might represent a small crater, partly filled in. The land was too rough and rocky for an automobile. The farmer lent us a team and a two-wheeled rubber-tired cart used as a handy get-around over the farm. It had two automobile wheels supporting a bed about six feet long and two and one-half feet wide, with a seat set up on it for the driver. Addie drove the two huge draft horses and I stood hanging onto a support, like some old-time charioteer, gazing out over the countryside while we swerved around or bumped over hummocks, sloughs, boulders and holes.

Except for obtaining a twenty-pound specimen that Mr. Staples already had, we didn't gain anything from that second trip beyond a fair certainty that the wheat fields and pasture land concealed no meteorite crater.

The Springwater specimens belong to the rather rare class of pallasite meteorites and are among the most beautiful we ever collected. Almost thirty years after I acquired the first Springwater specimen, two young scientists of the Fermi Institute in Chicago discovered in it a new mineral, one that was not known before either in the earth or in meteorites.

On our way home from Canada in 1931, as we passed through Michigan, we stopped to visit Stuart H. Perry, builder of a notable private collection of meteorites. I asked him particularly about the Beardsley, Kansas, fall, which had occurred October 15, 1929, while Alex Richards and I were in Mexico City.

Mrs. Roy Gaines of Beardsley had been awakened in the night, probably by the light of the fireball. She heard a noise, leaned her head out of the open window to listen, and heard two thuds in the yard outside. The next morning she told her husband; they hunted around and found two small stones weighing about a pound each. She wrote to me, but by the time I got back home and read the correspondence the meteorites had been sold to Perry. Perry told me only the two stones had been recovered. He had tried to locate more through correspondence, but without success. I asked if he had objections to my looking further into the fall and he said he had none.

We stopped at Beardsley, a little village in the extreme northwest corner of Kansas. The main street boasted a general store, a bank and a service station, where a group of men visited in the shade of the garage against the late summer heat.

Carrying a small meteorite in my hand, I went over to the group and introduced myself. I reminded the men of the fall two years before and talked casually and very briefly, then started to the store across the road, since they showed little interest and seemed even irritated at my interruption of their chat.

Half way, one of the men caught up with me and told me, in a low voice and with some embarrassment, that he had "one of those" at home. We drove the two and a half miles to his house and he hunted around until he located a walnut-sized piece of what evidently was part of a larger meteorite that had been destroyed by hammering. He told me he had found several stones out in the field that he never had brought in, some larger than his fist.

"Didn't you know that Gaines had sold stones like this?" I asked him.

"Yes."

"Why didn't you send yours in, too?"

"I don't know."

Several of his children were playing in his yard. Their ragged clothing, the house furnishings and the general run-down condition of the place spelled poverty. Why didn't this man, and others like him whom I met in similar circumstances at other times and places, gather in and sell those stones of whose value they were aware? Suspicion? Superstition? Any number of times I ran into this taciturnity, this reluctance. Perhaps it was hesitancy to "meddle with things from heaven."

The man in Beardsley agreed to look for more meteorites. I bought the little piece he had and arranged with the local bank to advance payment for others that might be brought in. During the next sixty days six stones, weighing from several ounces to twenty and one-half pounds, came from Beardsley. Some had been in the possession of the finders since October, 1929. Others were found during the autumn plowing which was in progress during the time of the several visits I made to the town during August and September of 1931. During the next two years a total of sixty specimens were recovered from this fall.

The man who plowed up the largest meteorite said that he had plowed up another of about the same size or a little larger. He carried it on his plow to the edge of the field and threw it over the fence on the roadside. After learning of its value he went to retrieve it, but meanwhile the highway maintenance men had cut away the bank, building a big grade and evidently burying the stone.

## 3

The market for meteorite specimens, always extremely limited, had waned to such an extent by 1930 that the only two dealers, Foote and Ward, were trying to liquidate their stock by marking prices far below normal. Their supply consisted mostly of left-overs from old finds, exampies of which long since had been purchased by the few institutions that still bought meteorites. Thus I was able to take slices or fragments of my recent finds and trade them advantageously for much greater amounts of the stock the dealers had on hand. Before making such trades I would make such cash sales as I could to institutions and collectors for ready money to live on. I retained the bulk of every find, cataloging these main masses as the Nininger Collection.

When Addie and I began visiting Denver and Colorado Springs with our summer school students in 1922, window displays of minerals were common. Offices and homes of geologists and assayers contained handsome display cases full of specimens. By the time we moved to Denver in 1930, however, well-cared-for collections had become very scarce. Nevertheless, I made it a point to look over all the rock and mineral collections I could locate in assay offices, windows of barber shops or small stores—anywhere there was a display of stones. Down on Larimer Street in lower downtown, in a dingy window, there was such a collection of minerals. The tenant was a bachelor of middle age who in response to my inquiry pulled out a drawer, reached in and brought forth a four-ounce stony meteorite, about the size of a golf ball although irregular in shape.

"We found this more than thirty years ago. We were stacking hay on a ranch near Doyleville, in western Colorado, and I was helping though I was only a youngster. One day when we got out to the field there was a black rock, maybe the size of a brick, lying next to the hay stack. We couldn't account for it."

His father had taken it to Gunnison to a collector who identified it as a meteorite and to whom it was given. The small piece shown to me had been detached from the larger stone.

I bought the little stone and later visited Doyleville and Gunnison. When the collector died his minerals had been given to the state college at Gunnison.

My inquiry about the "Jennings Collection" at the state college in Gunnison, Colorado, resulted in my being shown two or three cases of moderate size containing quite a number of small and poorly displayed specimens. The original mineral collection was said to have lined three walls of a room some sixteen by thirty-two feet, shelved to the height of a man's reach. It was reported that all of the large specimens had been hauled to the dump for lack of space.

I knew of several colleges which formerly proudly displayed fine mineral collections, the work of dedicated professors, that no longer spared space for such exhibits. On one occasion a janitor led me up dusty stairways, through narrow, dark halls and over a partially floored attic to the resting place of what once had been reputed to be one of the finest mineral collections in Pennsylvania. With the aid of a flashlight I scanned a huge pile, more than a ton, of dumped mineral specimens. Labels were scattered about and many fine specimens had been separated from their wrappings. Cabinet drawers lay empty about the distressing heap of specimens. The collection had been cleared out to make room for "more practical things."

Like treatment was given many other notable mineral collections during the early decades of the century.

Meteorite collections were down-graded in the same way. Harvard's mineralogical museum retired a large part of its exhibit in the late twenties. The American Museum of Natural History retired all but a few specimens of outstanding size. The National Collection in Mexico City, with its matchless quintet of superton specimens, lapsed into complete disuse and suffered severe losses. The California Academy of Sciences possessed a considerable collection, but no one attending it apparently had been able to label correctly some of the specimens after the disruption of the 1906 San Francisco earthquake and fire. During the thirties I recognized one of the collection's principal specimens as marked incorrectly, and found the almost complete mass of the Oroville iron lacking a label.

Harvard still possessed a magnificent collection but was not engaged actively in the study of meteorites. Yale had a large collection, but Dr. Ford told me that it had received no serious attention since about 1890. Amherst College possessed one of the half dozen finest collections of the time, but no attention had been devoted to it since the passing of Professor C. U. Shepard in 1888. Dr. Winchell of the University of Minnesota at one time had been active in collecting but had allowed other matters to absorb his entire attention. Dr. Hobbs of the University of Michigan had a keen interest in meteorites but most of his time was consumed by other concerns.

Western Reserve University, Columbia University, Wesleyan University, the University of Minnesota, the University of Iowa, the University of Nebraska, the State Museum of North Carolina, Tufts College, Drake University, the University of Wisconsin, Rutgers University—these and a few other institutions of higher learning had collections worthy of mention, but none were receiving attention.

For many years the meteorite collection at the Field Museum of Natural History in Chicago was the largest in the world. Oliver Farrington always was glad to assist me in obtaining the kinds of samples I needed for my lectures and to this end we made exchanges of portions of my finds on a basis that seemed mutually advantageous. It still ranks among the best in the world, but after Farrington's death in 1933 the growth of the collection slowed. The Field Museum disposed of a large collection of meteorite casts, the chief remaining source of information as to the surface features of the original specimens, which had been cut into slices. I acquired from the Field Museum a ton of large irons from the Arizona crater in exchange for a part of a small new find which I valued at about $500.

The market for Canyon Diablo meteorites at Winslow and Flagstaff, Arizona, had completely died out in the thirties. On one occasion I purchased several hundred pounds of small Canyon Diablo specimens for Dean Gillespie at fifty cents a pound. Large masses were cheaper.

During this period a 400-pound specimen lay in the open between the curb and sidewalk in front of a dwelling in Winslow, Arizona. Under a sidewalk grating downtown lay three great masses, subject to regular deposit of dust and trash. Officials of the bank under whose property they lay were not very clear about their ownership. These meteorites were rumored to weigh a ton, a half ton and 500 pounds respectively. Eventually I learned this was exaggeration. But the fact of their neglect is indicative of the casualness with which the subject of meteorites was approached. After persistent inquiry I learned that these meteorites belonged to the Barringer estate, and was given permission to exhibit them in the natural history museum in Denver. We weighed them and found their true weights to be 1,406 pounds, 570 and 160 pounds respectively.

Farrington had reported that the Academy of Science at St. Louis possessed specimens of more than forty meteorite falls, but a few years later the collection was stored, and when I went to see it in the late twenties I was told that it had largely disappeared. I was informed that another institution's collection of some ninety-odd falls met with much the same fate.

There had been a good deal of interest in meteorites from the first acceptance of their space origin until the century turned. In the early years there had been voluminous writings.

The prolific writers of the nineteenth century had been C. U. Shepard (1827-1888) and J. L. Smith (1854-1884). The next great names in the field of meteorites were Merrill and Farrington. Besides these two, Dr. Charles Palache was a third scientist who was helpful to me in the first years of my interest. He had charge of the important collection of meteorites in the mineralogical museum of Harvard University during the twenties and early thirties. Meteorites never were Palache's chief interest or responsibility; but he contributed importantly to the literature and I turned to him on various occasions for information and for support by way of purchase of my specimens.

In 1926 Dr. Palache cataloged the Harvard collection at 351 falls. The list grew apace during the next decade and portions of many of my early finds were added to it. Later much of this collection was retired for lack of space. Activity in meteorite study at Harvard slowed down and so remained for some years.

Dr. Charles P. Olivier included a very enlightening chapter on meteorites in his masterful treatise, *Meteors,* in 1924, but his chief interest was in the phenomena of meteors, their orbits and their relation to comets. He privately confided to me, to my great disappointment, that when a meteorite landed on the earth he lost interest in it.

During the middle and late twenties a number of young men began to evidence interest in meteors and meteorites: Dr. C. C. Wylie of the University of Iowa, Dr. F. C. Leonard of the University of California at Los Angeles; O. E. Monnig of Texas; and Stuart H. Perry of Michigan.

But it seemed that quantitatively meteorites were considered to have no meaning. The meteorite market was based upon the belief that after a meteorite had been described its value lay in its being listed in the catalogs of those institutions which took pride in the number of falls represented in their collections, or in its exhibit value if it possessed features of sufficient interest to warrant display.

The fading of scientific interest in meteorites, the deterioration of collections and the general lack of recognition of the quantitative significance of meteorites seemed to be related. The great collections of meteorites that existed all had been accumulated gradually through acquisition of accidental finds over long periods of time. Yale's collection had begun with the stones of the historic Weston, Connecticut, fall of 1807. Amherst's began soon after. The United States National Museum collection was benefited by gifts from various individuals. Ward's Natural Science Establishment was the most available market for any meteorite found, but the bulk of Ward's material was obtained through purchases of collections that themselves had been accumulated slowly. Harvard, American Museum, Field Museum, all had built their collections through purchases of old, established accumulations.

The Nininger Collection was unique in that it was being established mainly by means of a planned search for specimens which would be added or which would provide means of exchange for others to be acquired.

In about 1930 when I was beginning to build the base for my collection, Ward's was offering the remnant of the Rochester University collection at ridiculously low prices, due to the general disinterest in meteorites. The fate of this Rochester collection furnishes a good clue to the failure of the study of meteorites to catch on. Rochester University—which happened to be located in the same city as Ward's Natural Science Establishment—had not really taken the study of meteorites seriously. By exchange of a portion of one of my early finds and by borrowing some money I was able to acquire several very fine meteorites of the Rochester group at a small fraction of the prices at which specimens of the same falls had sold previously. I had taken pains to learn that only four and in some cases five institutions in the United States had samples of these falls in their collections. No one seemed to think there would be any need for more of these meteorites than those few institutions then possessed. The meteorites had been described; the specimens held were sufficient for exhibit. What more did anyone want? In this single instance I acquired approximately forty-two pounds of the Gilgoin, Australia, stone; thirty-one pounds of the Estacado, Texas, stone; and thirty-three pounds of the McKinney, Texas, stone. At the same time, I obtained good-sized specimens of several irons.

Because I was able to make fast progress in building a substantial collection, because depressed interest in meteorites had led to depressed prices, and, finally, because the interest created by my lectures and writings created a new crop of collectors, my program of search became reasonably self-supporting even before it yielded any significant number of new discoveries. Thus I became a supplier of meteorites to collectors as well as a searcher for them.

*Nothing in the world can take the place of persistence. Talent will not: nothing is more common than unsuccessful men with talent. Genius will not: unrewarded genius is almost a proverb. Education will not: the world is full of educated derelicts. Persistence and determination alone are omnipotent. The slogan "Press on" has solved and always will solve the problems of the human race.*

*—Calvin Coolidge*

# 5. ON VARIOUS TRAILS

In Santa Fe, New Mexico, while on a truck delivery during the spring of 1932, I stopped for a brief visit to the anthropological museum there, intending to inquire about a small meteorite that recently had been found in a pottery vessel in an ancient ruin. I parked my truck in the lot and went in.

As I was passing among the exhibits, quite unexpectedly I met Dr. Alexander Wetmore, director of the United States National Museum, who happened to be in Santa Fe on a one-day visit. On a bench outside the building Dr. Wetmore and I sat and visited, turning our talk to meteorites. When he asked how our work was going, I grinned and waved at my truck parked nearby. On the spot he offered a tentative arrangement for some field work the following summer in the northwest part of the country on behalf of the National Museum.

We made vacation arrangements for the children, and Addie and I undertook several projects, including an investigation into the Port Orford, Oregon, meteorite story.

The Port Orford case is an enigma. This famous pallasite has never been rediscovered since it was seen first in 1859 by Dr. John Evans, a government geologist, who reported that he detached a small sample from a parent mass estimated at 22,000 pounds, but died before actually mapping the site. We, like other searchers, found no trace of it.

Some scientists became convinced the great mass never existed, that the sample collected represented only a small mass and that Dr. Evans had become confused in his memory as to where he had obtained it. To me it appears unlikely that a geologist could detach a piece of pallasite from any parent mass without holding in his mind a very reliable picture of the source of the fragment. Field experience has prepared me to understand just how plausible it is that such a great meteorite could exist, just as described, and yet remain unfound. Indeed, I should be greatly surprised if it is ever rediscovered though I feel very sure it exists.

A miner of the area reported seeing the meteorite as a boy of fourteen in 1882 and finding it again in 1900 some thirty to forty miles southeast of Port Orford. In the late thirties he still talked of trying again to locate it.

The legal aspects involved in the ownership of large meteorites often tend to keep them from coming to light. It has been rumored that the Port Orford meteorite may have been found again, but the finder feared to make known the fact lest the specimen be taken away from him.

Meteorites are where you find them. People often suggest searching for meteorites in areas where rocks are abundant, but usually I shun such places, because in an area where rocks lie everywhere hunters will become confused and will tire of looking at every stone. If there is only an occasional rock, a searcher is much more apt to take a second glance to see if it might be a meteorite.

A daylight meteorite fell near Archie, Missouri, on August 10, 1932, while Addie and I were in the northwest. Some time after our return home I wrote to the National Museum proposing that we cooperate in field work in the Archie area. I suggested that the museum advance cash to cover my expenses and in return receive specimens to cover its outlay, the findings of the survey to be written as a joint report. The museum offered rather to buy $200 worth of meteorites, if I could find them. This plan made it necessary for me to work on borrowed money, but it also left me free to do as I chose with my time.

During the couple of weeks that I spent at Archie, some fifty miles south of Kansas City, interviewing witnesses to the afternoon fireball, I drove regularly to and from the town of Harrisonville about ten miles north of the site of the fall, and noticed that about midway of that distance there lay a group of nicely cleared farms in the usually timbered country, with no rocks anywhere in sight.

One day, finding myself with some spare time, I decided to do some work in this rockless area, on my assumption that meteorites fall one place as well as another. I interviewed farmers, carrying with me some small meteorites for illustration, and suggested the likelihood there were some meteorites in the community, adding that a fair price would be offered for any that might be found.

After spending two or three hours with a dozen different farmers I drove back to Archie.

Two days later the wife of the first farmer I had talked with came to see me, bringing a meteorite.

"Is this what you were talking about?"

"It sure is. Where did you get it?"

"Right after you left our house my husband told me he knew he had plowed one up sometime, but couldn't remember where, so he wouldn't talk."

I recalled how the man had stood perfectly silent while I talked with his wife. I couldn't tell if he was resentful of my interruption of his chores or if he was just thinking. He had been struggling with his memory. The next morning before he arose from bed he recalled how he had plowed up the meteorite in the potato patch and had tossed it over against the hedge.

As soon as the neighbors heard of the payment I made for that meteorite they started looking around. In the course of a few years forty stones were found, all proved by their distinctive structure to belong to the same fall. A fireball was known to have been witnessed throughout Missouri and eastern Kansas in about 1915. As nearly as could be reckoned from available accounts, the Harrisonville stones probably originated with that fireball.

This experience reinforced my belief that meteorites are present, though not abundant, everywhere, and that they can be located in some quantity if people can just be trained to recognize them. A little explanation and the exhibit of a few samples to a number of persons will arouse some interest, but payment for the first meteorite located in a community very often will lead to recovery of others—maybe just a few in a ten- or twelve-square-mile area, maybe one or more on every farm around.

Witnesses of the Archie, Missouri, fireball reported that it had disappeared suddenly, whereupon a cloud of dust had formed, about twice the diameter of the full moon. Calculations showed the dust cloud was about twelve miles above the ground, the average height at which a meteorite ceases to burn during its descent. A stony meteorite usually breaks up at about that height, the majority of the mass falling as dust particles, but with chunks of meteoritic material sometimes surviving to reach the earth.

One of the most useful accounts of the Archie fall came from a high school senior who at first was reluctant to speak out at all. I presented a lecture in the high school, including information about the recent fall, and at the close of my talk interviewed all those who volunteered first-hand information. As I was leaving the building two boys came to me.

"Bill has some very interesting facts to report, //you can get him to talk," they told me.

I sought out Bill and asked him to come with me to my car, where I inquired whether he had seen or heard of the phenomena associated with the fall. When he replied affirmatively I asked why he had not spoken out. He explained that he knew some of the "wise guys" would ridicule and make a public spectacle of him. Now he was willing to tell what had happened. He said he was down along the creek, about three-fourths of a mile west of his home, hunting squirrels among some rather large trees, when suddenly he heard what he thought at first was the firing of a shotgun, except that it seemed too loud. This sound soon was followed by another and then a rather disturbing roar. Then Bill heard a noise like buckshot striking the leaves and branches of the trees above him. His thought was that someone was playing a prank, and he considered it a pretty hazardous joke.

"I was frightened and started for home, and about that time something struck in the water of the creek a few feet away."

He said the splash was like that of a rock the size of a man's fist. A boy of his age and this place would be familiar with the splashes made by fish, frogs and turtles as well as by stones; it was safe to assume that he had heard one of the stones which had fallen, of which several had been recovered near where he had heard these sounds.

When Bill reached home he learned that his father had observed the fireball and "smoke trail" of the meteorite. His father also had heard sounds like those the boy heard, and he had felt a showering of small "gravel" on his hat and shirt. The youth's sister, eight years old, had come from the opposite side of the house where she had been playing, frightened and half in tears.

"Daddy, it's raining rocks out here!" she had cried.

The fact that the showering of small particles had been heard or felt by three members of this family, in two locations three fourths of a mile apart, became more significant when it was matched with the testimony of a dozen neighbors who had been enjoying a watermelon feed under a tree at a farm a few miles away. All had heard what sounded like hail pattering on the shoulder-high corn in an adjacent field. These three occurrences of showering gravel followed shortly after the detonations from the meteor, and the locations were in a straight line extending a distance of six miles. Another report of a small stone striking the side of a house about a half mile to the south of this line also sounded entirely plausible.

This sprinkled area lay under the projected path of the fireball and was between the point above which the final burst had occurred and the area where seven stones, totaling eleven and a half pounds, were recovered.

A little calculation based upon even the meager facts that were submitted indicated that the collected stones from this fall were a mere bagatelle compared to the tonnage that must have rained down in the area. By our efforts, the seventh recovered stone was located, but we were unable to recover a single grain of fine material. Our information was obtained four months after the fall. The area was heavily vegetated and had been subjected to severe rains.

Several times I have "just missed" being a witness to one of the awesome sky spectacles that have sent me searching for earthly remains of "visitors from space." One instance was the Pasamonte, New Mexico, fireball of March 24, 1933, a meteor that was unusual in many respects, as were also the stones that months later were recovered along the path of its flight.

With my son Bob, then fourteen, I had gone to the town of Clovis, New Mexico, to obtain a meteorite that had turned up in response to some stories the local newspaper editor ran in his paper for me. I was awake, restless, at 5:00 **A.M.,** and kept peering from the north window of our tourist camp cottage, looking at nothing. Clouds obscured the Clovis sky, but, perhaps by some vague abnormalcy, they conveyed a hint of the astounding phenomenon that was occurring behind their curtain. For while I stared recurrently from the window, Charlie Brown, a cowboy, at breakfast 200 miles to the north near Clayton, New Mexico, was making meteoritic and photographic history.

Charlie noted that the clock was striking five just as he sat at the breakfast table. At that moment the sky lighted up with noontime brilliance. With astounding quickness of mind and hand he snatched up a little pocket camera, unfolded it as he ran outside, pointed it toward a great, advancing ball of fire and snapped the shutter. When he glanced up again, the meteor was disappearing over the housetop.

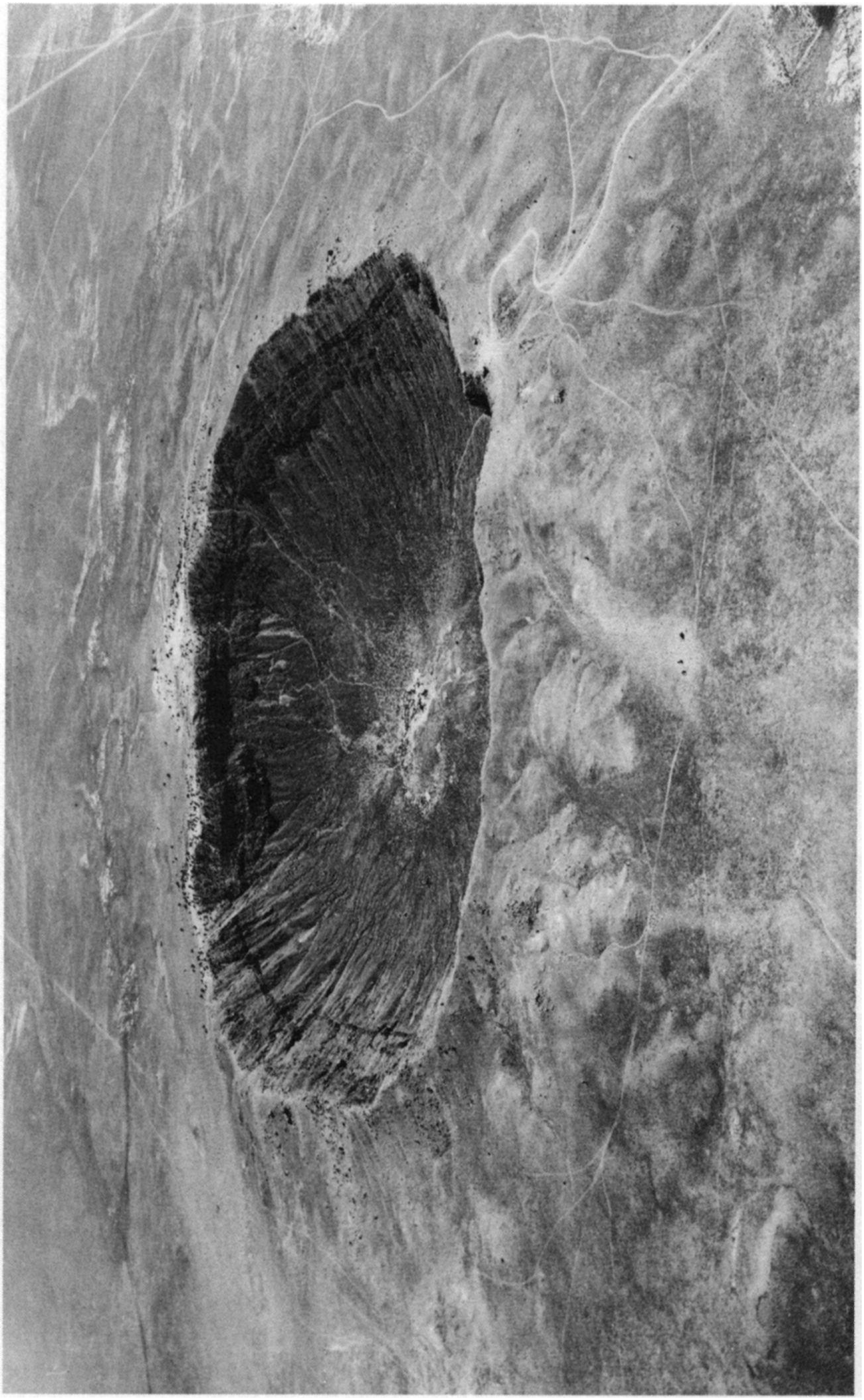
What he had seen, that I would have given much to see, was one of the greatest of modern meteorite falls. It was weeks later before I knew of Charlie Brown's picture.

That was the nature of most of my meteorite searches. Many were total duds. Many more brought only "delayed action" results. Others would take a sort of "one thing leads to another" course so that an initially small find, or slight lead, might snowball into something big. The last was the case with Pasamonte. By luck, Bob and I had been—almost—in the right place at the right time. Before we finished our investigation we received unprecedented sketches and photographs of the accompanying luminous dust cloud, as well as the phenomenal Brown photo, and a number of specimens of a rare kind of stony meteorite. In the meantime, a number of specimens were destroyed through ignorance and out of our poor luck in not getting to the right places fast enough.

From Clovis Bob and I drove to a farm near Melrose, twenty-five miles west, to obtain the meteorite we had come to purchase. The farmer told us he had plowed up the meteorite long before and thrown it into a ditch to save his plow. Years afterward he needed a weight for his go-devil, an implement used to cultivate row crops, and remembered the heavy stone. He had been using the sixty-eight-pound meteorite on the go-devil ever since.

As we paid him, he said he wondered if "that thing might have come out of one of those falling stars, like the one I saw this morning."

He described the fireball he had seen. I thought perhaps the sale of his stone had exaggerated his interest in an ordinary meteor. When we got back to the little village of Melrose we parked in front of the tiny cafe,



*Collecting meteorites from Haviland crater.*

*A section through a portion of the meteorite horizon of the Haviland crater, showing meteorites in place (painted white).*

opened the car door so the meteorite could be seen lying on the floor between the seats, and I started conversation with some men standing nearby.

Did they know anything about meteorites? Pretty soon one of the men spoke up, "I saw one this morning."

As others added their stories it became evident that a spectacular fireball had crossed the northern sky. After I made some notes on their observations, Bob and I drove on west, then north, stopping wherever there was a settlement. We asked about size, appearance and direction of travel of the fireball and drove accordingly, until eventually we had circled the end point—the point where the light went out—and now the reports began to describe the fireball as being in the opposite direction.

Descriptions varied. The meteor was as big as the moon. As big as a baseball. It was an advancing wedge of flame. It was a whirling ball. There were two fireballs, three, a half dozen.

In observations on direction and altitude I have found lay judgments cannot be depended upon as accurate within limits of less than thirty degrees, but I have sometimes interviewed professional geologists and physics teachers who did no better. Even inexpert accounts can provide the basis to determine whether a meteor passed on one side or the other of a certain point, and for calculating the limits of visibility and the vanishing point.

For two days Bob and I searched out eyewitnesses to the Pasamonte fireball, driving ahead as indicated, and established the approximate landing area. Meanwhile press reports placed the landing in five different states. A Denver newspaper caught up with me by telephone, queried me, and then ran a story and picture of the "meteorite," reportedly "found" in Brighton, Colorado, some 300 miles north of the area in New Mexico where the paper chided me for still hunting it!

Over a period of four months, intermittently, I interviewed witnesses in many towns of New Mexico, Colorado, Kansas, Texas and Oklahoma. The spectacular display was plaintly visible even from points as remote from one another as Cheyenne, Wyoming, and El Paso, Texas.

Ultimately it became evident that the phenomenon was more spectacular than even the most dramatic accounts by witnesses—the fireball actually was cubic miles of incandescence, accompanied on its fifteen- to twenty-second flight by a discharge of material which produced a visible column of dust a mile in diameter and lasting ninety minutes or longer.

Aerial disturbances shook buildings and rattled windows as far as ninety-five miles to either side of the course. In the vicinity of the end of the visible flight, many residents insisted they had suffered throughout the entire day following the fall from a throat irritation like nothing they had experienced previously or since.

It was some months later before I was able to continue with the fireball survey. An unusual feature of the Pasamonte meteorite was that it ceased to be incandescent at an unusually high altitude of seventeen or eighteen miles, and all of the recovered fragments were deposited *behind* the end point, rather than at some distance beyond.

We had made several trips into the area over a period of months before I happened to stop at the Pasamonte ranch.

"Did you find any of that meteorite that fell near here a while back?" I asked the head man. I showed him a fresh-fallen meteorite found a few years before, picked up before it had weathered any.

"I saw it land somewhere in the vicinity," he told me. "Maybe it burned itself up." He studied the specimen I held. "I thought they were all iron."

"No," I said, "most meteorites are stony with a little iron mixed in."

He looked at it closely. "That looks like what a herder brought in that morning. Pacheco was in camp nearly two miles from here and came running in frightened out of his wits, ready to quit his job; he said it rained rocks all around out there and he brought one of them in. But I didn't believe him because I thought meteorites were always iron."

The boy had quit; no one knew where he was.

"What did you do with the rock he found?" I asked the ranchman.

"I don't know. We all looked at it and some of the men pecked at it with their knives. It was kind of soft, with that black crust on the outside like the one you showed me."

He looked around and finally found the stone way back in a corner of an old cupboard all covered with dust. It was just a little thing, but as quick as I saw it I knew he had run down our meteorite and we began to go around and talk to the ranch hands. Finally I located two or three fellows who told me they had seen such stones.

"We had quite a lot of them but we broke them up."

"What did you do that for?" I asked.

"We thought they might have something in them."

They told me they had picked them up in the morning the big fireball had streaked across the sky. I got them to hunting around through their shack and they found three or four stones that hadn't been cracked open.

Eventually about a hundred fragments were recovered, scattered widely in the sparsely settled country. I kept raising the price I paid to induce people to hunt for the little stones until finally I was paying $3.00 an ounce.

One of the finest specimens was recovered by O. P. Gard. Ten days after the fall, according to his wife's diary, Gard was driving a tractor when he noticed a little black stone lying on top of the buffalo grass. The stone didn't seem to belong there, so he veered the tractor to avoid running over it, and stopped to pick it up. Gard was entirely unacquainted with meteorites, but he suspected the little black stone might have come from the big fireball he had seen ten days before. He wrapped it carefully in a piece of tissue paper and when we encountered him much later, the specimen was still fresh and unspoiled. It weighed an ounce.

It was nine months after the event before finally I held in my hand at the Pasamonte ranch a fragment of the aerolitical stone—the meteorite—that had caused the great spectacle of light, the turbulence, the dust cloud, the fright of shaken witnesses, of March 24, 1933. The material was almost like volcanic ash beneath the outer fusion crust, so friable that in all probability no large mass landed anywhere intact. All the recovered specimens together weighed a little less than eight pounds. Pasamonte is of the rare type of stony meteorite known as *Howardite,* and portions of the scant material recovered from this spectacular New Mexico fall have found their way to museums all over the world.

On my several trips into the Pasamonte area, I made it a point to instruct all of the ranch hands on recognizing both fresh and weathered meteorites in the field, for the very good reason that I was sure other falls had occurred during centuries past in the same area.

On one occasion as I drove into the ranch headquarters and turned to park in front of the little company store, I noticed a fist-size stone just inside the gate which appeared to be a fragment of an old stony meteorite. A second piece lay near by. After parking I went back and examined the two pieces. They were both meteoritic. I took them into the ranch office and asked the manager if he knew where the fragments came from. He told me that Fidel Lanfor had brought them in.

After talking with the various ranch hands I drove to Lanfor's farm. There, lying in his yard, was a considerable pile of fragments like those I had picked up in the ranch yard. Fidel told me he had found a "big rock" in his field and thought it might have some diamonds or gold in it, so he took a sledge and broke it up.

"But you didn't find anything of value in it, did you?" I asked.

"No," he said.

"But you knocked about a hundred dollars out of it," I told him.

Charles M. Brown, whose snapshot of the fireball in motion made scientific history, was manager of the Lyon cattle ranch, situated in a narrow valley about twenty-five miles southwest of Clayton, New Mexico.

For several weeks after the meteor I was in the field almost steadily. On May 16, Director Figgins of the museum in Denver wrote to Charles Brown, having received word that Brown had photographed the smoke cloud left by the March 24 meteor. Mr. Brown replied under the date of May 20 that his picture of the smoke cloud "would be of no special benefit to you as it is a very poor print," etc., but "I do have an excellent picture of the meteor in flight which I was very fortunate in getting, which shows very plainly actions of the meteor which you could not see with the eye. . . . Some time ago I wrote to Mr. Ninninger (sic) to call on me, that I thought I could possibly help him in determining which way this meteor went. . . . I would be glad to give you any information I can on this meteor at any time."

The letter he mentions never reached me. Neither Dr. Figgins nor I could understand how he possibly could have gotten a photo of the meteor in flight, but we agreed that the photograph should be examined.

When I arrived at the Lyon ranch near Mt. Dora, New Mexico, Brown was not in. I explained my errand to Mrs. Brown, adding that it was difficult to comprehend how such a feat as a photograph of a meteor in flight could have been accomplished.

If I knew Charlie, Mrs. Brown told me, I would understand. "He always does things that way, on the spur of the moment, never stops to figure or discuss; just goes ahead and does it."

Charlie Brown's photograph is dominated by the great glowing ball of the meteor, just at the point of emitting one of its periodic incandescent flares, streaming a luminous tail behind it.

Charlie told me that he habitually kept his camera on a radio cabinet near his chair at the breakfast table. He described matter-of-factly how the unearthly light turned everything into mid-day, and he had simply grabbed the Kodak and dashed outside, opening it as he ran, pointed it and snapped the shutter. Then he wound the film and tried for another shot, but the second one was not good; he believed the light was too intense after bursting of the big fireball.

I had him re-enact the scene for me, timing him carefully. The entire sequence required eight-and-a-half seconds, an interval that was consistent with other reports that the fireball was visible for fifteen to twenty-two seconds. Consequently, for a Charlie Brown, it had been no difficult feat.

As quick as Charlie was on the trigger in taking his historic snapshot, the film lay in the photo shop for weeks before being developed. Two processors declined to print it, seeing nothing worth printing.

The meteorite which the farmer near Melrose had used on his go-devil and which had taken us to the area at the time of the Pasamonte fireball, is interesting and unusual in its own right. It is a gold-bearing aerolite—that is, a stony meteorite containing bits of gold.

Some weeks before the March 24 fireball, I had been in western Texas on another search. Hunting had not been good and I turned home, through New Mexico. As I approached Clovis, then a small village, I was impressed by the miles of almost level country, relatively free of vegetation and with no rocks in sight. I drove on into the town and since it was Saturday and the schools would not be open I headed immediately for the local newspaper office. There I met Pete Anderson, editor of the Curry County News. The walls of his office displayed a number of Indian relics. After admiring his collection, I asked Anderson if he had ever run onto any meteorites during his field trips.

"I'm afraid I wouldn't know one if I saw it. I always thought I'd like to find one, though."

I pulled some samples from the little bag I carried, tossed them on his desk and began to explain the differences between meteorites and ordinary rocks. I suggested that he write a story for his paper, explaining how to recognize meteorites, telling the farmers of the area that there might be a meteorite or so among the rocks they probably had been throwing from their fields into ditches and fence corners for years, and relaying an offer from me to buy any that were found.

Pete wrote a very good story. His paper went out on Thursday and on Saturday Guy Groves brought in his go-devil "weight." Pete promptly forwarded a sample. I sent a check and arranged to pick up the stone on a future trip, the trip which coincided with the Pasamonte fall.

The news that Mr. Groves had sold a rock that had been knocking around the place for years was the occasion for another newspaper story. More meteorites showed up.

When I asked my chemist, the late Mr. Fred G. Hawley, to analyze the Melrose stone, he discovered a trace of gold in the meteorite.

Hawley was chief chemist for the Inspiration mine and smelter of Anaconda Copper Company at Miami, Arizona. I had met him during a trip which Addie and I took with the children in 1925-26 and began at that time sending my meteorite samples to him for analysis.

Fred Hawley was extremely cautious. He wrote me in detail of the chemical test he made on a sample of the Melrose meteorite.

"If I am correct this is surprising, for I understand that Au (gold) has rarely, if ever, been found in meteorites. . . . I think I am right about the presence of Au; but before certifying it I should like to make two more tests by fire and run them a little differently to separate the gold, if you will send me more material.

"If I find gold is really present I think you should have some other chemist, experienced in this work, check my results so as to leave no doubt in the minds of other scientists regarding its correctness."

Mr. Hawley's further tests agreed with his original finding, and his determination was confirmed by assays by the American Smelting and Refining Company in Denver.

Fred Hawley need not have been so modest. When Dr. Harrison Brown carried out a program of re-checking old meteorite analysis during the 1940's, using the newest methods, he stated that those made by F. G. Hawley were among the very best.

When I published a scientific description of the Melrose stone, a problem arose. As a gold-bearing meteorite, it made headlines in newspapers all over the world. Some news men made it sound as though my meteorite hunting had the objective of acquiring precious metals, and finders of meteorites began demanding high prices. Worse still, some fine specimens were broken up in efforts to recover their supposed content of gold. The $50 that I paid Mr. Groves for his meteorite was about forty times the value of all the gold it contained, but this fact seemed less newsworthy and for years we had to contend with the misconception that meteorites were a source of precious metals.

As a result of Pete Anderson's local stories and the publicity accorded the gold-bearing Melrose stone, two falls of unknown date were discovered in Curry County some thirty miles away from Melrose and two other very old falls were recovered about the same distance in the opposite direction. A second stone of the Melrose fall also was recovered. Then there was no more activity in the area until 1961, when a farmer bumped into a 600-pound meteorite in the subsoil. He sent it to the Smithsonian.

2

Before any specimens had been recovered from the famous Pasamonte fall, westerners were treated to another great fireball. This was the August 1933 daylight meteor of Sioux County in northwestern Nebraska, which created a disturbance all over that part of the state. Detonations were heard over a distance of 150 miles; within the central fifty miles of this area cattle stampeded, horses ran away, farmers were startled into falling from their machines in the fields; wild pheasants were set into outcry.

Yet the stones recovered from this fall totaled only about thirty, an aggregate of six pounds, the largest of which weighed three pounds.

How could such grand pyrotechnical displays occur without leaving some great memorial in the form of masses of stone or iron? The Sioux County fireball, like those of Archie, Missouri, and Pasamonte, New Mexico, added to my growing conviction that the dust clouds so often reported to accompany fireballs carry a great share of the disintegrated meteorite and that in many cases no great mass survives.

I first heard of the Sioux County fireball when the phone rang at our home in Denver at about 10:20 on the morning of August 8, 1933. The caller was my nephew, Edgar Nininger, who was working on a farm that summer about four miles east of the city.

"I just saw a great meteor," he told me. He said he had been riding his horse from one field to another when a streak of fire appeared in the clear, cloudless sky, descending almost verically until it was cut off from view by an intervening haystack.

At once I drove out to check with Ed. He had marked the exact spot from which he had seen the streak of fire, and the haystack was a good landmark. I set up a forester's compass and noted direction and elevation according to his observation: about fifteen degrees east of due north, the almost vertical descent bearing just slightly to the westward. Ed judged the fireball was visible about two seconds.

I returned home. Addie already had packed our grips and a lunch for us. I obtained from the press services and newspapers the reports they had received, and we got into the car and headed north.

The nearly vertical descent, as Edgar had witnessed it, gave no indication of whether the fireball was moving toward or away from him. We never drove directly toward our objective, but to one side or the other, in order to obtain reports from observers who could give us directional information, modifying our route as we progressed. We knew this fireball had been witnessed farther north, so we drove fifty-five miles north to Greeley, where the local editor gave me the names of witnesses.

We contacted them. Each observer was requested to stand in the spot from which he viewed the fireball and describe its appearance, whereupon I took notes and compass bearings on the vanishing point of the fireball as it was seen by each. Reports in the Greeley area were not noticeably different from Edgar's account, indicating the object must have been a considerable distance away. Also, Edgar's report that the meteor was still burning when it disappeared behind the haystack was a good indication that it was still quite high and the landing place could be 150 to 250 miles off.

Locating the end point is an important first step in the hunt for a newly fallen meteorite. If the fireball appears to reach the horizon the meteorite probably has traveled many miles beyond the point of disappearance; if the light has been seen to go out high above the earth it can be presumed that the surviving fragments have not traveled very much farther onward from that spot.

Paradoxically, to the observer the reverse seems to be true; the light that disappears "behind the haystack" or "just back of the barn" or "on the other side of the hill" is the one that convinces the untrained viewer that the meteorite "fell right over there."

We continued northward from Greeley. At Cheyenne, Wyoming, sixty miles farther, we interviewed observers again, and then went on to Torrington, another eighty-seven miles north. Here the reports indicated a vanishing point considerably more to the east; also witnesses said the fireball had disappeared while yet well up in the sky. This indicated to them that the meteorite had burned up before reaching earth; to us it meant simply that it had quit burning.

' We stayed overnight at Torrington, taking a number of bearings with the help of various witnesses, and next morning we drove eighty-three miles farther north, to Lusk.

At Lusk, observers pointed southeast instead of northeast, indicating we had passed beyond the end point of the fireball. We turned east into Nebraska, stopping at each town until we reached Crawford, where observers pointed almost due south. A little farther, at Chadron, witnesses reported the fireball had disappeared in a due southwesterly direction.

Now we turned south and kept on in that direction until observers began to point north of west. Here, we knew, we had just about encircled the end point of the fireball. Now we were ready to plot the course of flight and to indicate the general area in which surviving fragments would have landed.

Our preliminary survey covered the whole west half of Nebraska, parts of eastern Colorado, southeastern Wyoming and northwestern Kansas. We determined that the course of the meteor was fifteen degrees west of north and that it had vanished at a point over the Niobrara river, half way between Agate and Marsland, Nebraska. Its descent was at an angle of about 30° with the horizontal, and it had disappeared about eight and one-half miles above the ground. On the basis of these known facts and probable velocity and other contributing factors, I had to estimate how far ahead of the point where the light had disappeared the landing place should be expected.

Three witnesses in Denver reported the object as "a mile or more northeast." A Colorado supreme court justice, viewing the fireball from Estes Park, was sure it had fallen in nearby Devil's Gulch. A newspaper editor in Berthoud, Colorado, relayed positive assertions that the object had fallen in a field five miles east and two miles north of that town—nowhere near the ultimate recovery site—and warned me not to bring any great number of persons to help in the search, for the owners of the field did not want "a lot of people tramping over their land." A motorist driving west from Gothenberg, Nebraska, was just as certain the meteorite had fallen in the hills near that town. And a salesman on the road fifty miles southeast of Denver—more than two hundred miles from where the meteorite actually struck—was so certain it had fallen in a field next to the highway that he made two trips back from Denver to search the pasture land adjoining the strip of road where he had been driving. Fishermen near Elk Mountain, Wyoming, spent several hours searching for the object they had "seen" fall in the hills "nearby."

What each of these witnesses possessed that was useful to the hunter of the meteorite was the observation hardest to extract from them: an accurate report of the direction the fireball was in relation to where they stood when it vanished. They all were so eager to help that they wanted to provide the exact location where the meteorite landed, instead of the simple directional reports that could help to establish the fact.

By taking the varying observations and plotting them against each other, knowing the distance between the observations, it was possible to bring together the angle of descent and the horizontal path of passing and come up with a pretty good idea of the spot on earth toward which the meteor was headed. Then we marked off half* of the distance from the

***This might be more or less than half, depending on air currents, angle of descent, height at burn-out and other factors of the particular instance.**

point of the fireball's disappearance back to this spot to allow for further flight after burn-out, and drew an ellipse with this as the long axis.

I sat in the car on the Nebraska prairie, with map, ruler, protractor, pencil and paper, and plotted a space some fifteen miles long by about ten wide, over some part of which I figured the fragments of the meteorite were scattered. Then we went into the area enclosed by our ellipse and canvassed it house to house, talking to the residents, showing them a freshly fallen meteorite so they would know what to hunt. This survey and search were continued through more than a year.

When fragments eventually were recovered, they were found within the northwest quadrant of the target area I had drawn.

The first fragment found was picked up in a potato field, where two farm boys named Yohe were hoeing, at the same time teasing the hired hand working with them. The light of the meteor startled all three and the following detonation frightened them; that evening the hired man complained to the parents that the boys had thrown a rock at him. The boys denied this charge, and it was suggested that perhaps it was the "thing in the sky" that had nearly struck him. The next day, working the same field, Homer Yohe picked up a stone with a shiny, glazed black surface that later was identified as a meteorite.

Again and again we returned to the ellipse we had plotted and endeavored to contact every inhabitant.

One man I remember particularly well.

"No, it didn't fall here," he told me. "I saw it. It fell way south, maybe fifty miles. A team ran away with a binder down there. You're in the wrong spot."

I explained to him I had heard about the runaway team, but that it is a known fact that a big fireball will frighten horses, cattle, even human beings all along its course and far to either side of it. He was not to be convinced that the meteorite had fallen in his own locality, but finally after long protest he agreed to watch as he herded sheep. A week later he sent me a little meteorite, one of the finest specimens I ever obtained, found right on his own farm.

The north curve of our ellipse lay in sand hills where auto travel was difficult and treacherous in 1933, and I reached that northern point only once. It was late in the day when I made my last stop and I asked if there were any other farms nearby to the north. There was just one more house, about a half mile farther into the sand hills, on a road that was scarcely passable for my car. My informant agreed to relay word of my search to his neighbor, but evidently he never did.

More than a year later this unvisited neighbor picked up the largest fragment recovered from the Sioux County fall and he took it to the stock corral on the railroad where the cattle were being loaded and passed it about for all the cowhands to see. With their knives they chipped about half of the nice fusion crust away and finally one broke the stone in half with a hammer. It was in bad shape when it finally reached me, but obviously it had once been a fine specimen, probably equal in weight to all the other fragments recovered.

3

Problems of interpreting fireball reports had plagued us ever since the 1923 fireball. In that case each of two farmers living 300 miles apart and in opposite directions from McPherson insisted the fiery object had landed in his own field, while my own observation placed the location of fall far from both of them. The largest distance ever recorded between fragments of the same meteorite is about twenty-eight miles, although there have been cases where news dispatches have reported a fireball has "fallen" at localities as far as 600 miles apart.

The public nearly always was willing and anxious to help. There were many futile searches, but the wild goose chases were governed by the natural law of averages, not by malice. Natural mistakes were to be expected. All I really asked was that anyone volunteering information simply tell me what he knew, or thought he knew. Humorous incidents often accompanied my putting of two and two together. Measuring and utilizing the myriad untrained observations of witnesses was endlessly interesting.

Ignorance of the true behavior of meteors was widespread. People just would not be convinced that meteorites cease burning several miles above the soil. Therefore when the fire-streak is "traced to the ground" the real fact is the object was so far away that at a height of several miles it still passed over the observer's horizon. Excepted would be the large crater-forming meteorites which would be destructive over an area fifty miles around the fall.

There is no mystery as to why the light of a meteor disappears at several miles above the soil. The only reason for the light is friction with the atmosphere due to the extremely high speed of the incoming meteorite. Friction causes a slowing down, and when the meteorite has been slowed down to about the speed of a high-powered rifle bullet the friction is no longer sufficient to produce burning. The light fades out and the meteorite continues on its way to the earth. If it is farther than a few miles from the observer it is invisible. If a fireball vanishes at a height of ten miles then it may be anywhere from fifteen to thirty miles from its target depending on what has been its angle of approach.

The illusion of the distant fireball's seeming to reach the ground nearby is almost universal. In the vicinity where the stones actually fall the opposite illusion often obtains. Because the burning ceases and the fireball disappears high in the sky, observers are very apt to argue that "it was all burned up."

Discrepancies regularly accompany reports of a meteor viewed over a wide area. Suppose we take a hypothetical fireball, witnessed across an area three hundred miles wide. The site of fall will appear as the hub of a wheel, with spokes radiating out in every direction. At the end of each spoke are witnesses of a particular vicinity; from only two of these areas, those in a direct line with the object's flight, will the meteor have appeared as if moving in a straight path. From the end of the spoke following the line of approach, the meteor will be seen as a long streak ahead; from the end of the opposite spoke, far *beyond* the landing place, the meteor will not be visible; from a point closer in toward the hub, the passage will appear foreshortened, a streak of fire of much briefer passage.

Actually, our wheel is lopsided, for the viewers in the area whence the fireball came may be farther away, the spokes elongating the closer they are to the actual path of approach.

From each witness, at the end of each spoke, one gleans an additional bit of information to be used in plotting the area of fall. Then, moving inward toward the target location, the investigator will find that witnesses within perhaps thirty or fifty miles of the landing place will have heard detonations or sound disturbances. But within a still smaller area immediately around the landing place, very near to the end point, usually there are no observers at all, unless, perhaps in daylight, an individual chances to be looking at just the right spot at the right time and sees the meteorite fall as a black-appearing object. Sounds in this immediate area are mere thuds, or patterings, as of things falling.

The great rush of light and sound are experienced farther away from the end point. The horizon beyond which the meteor seems to pass out of sight may be 200 miles distant if the object is eight or ten miles high when sighted, even though it may appear that the meteorite has fallen behind a nearby obstruction such as a barn or haystack. If the light is seen to go out, or "burn up," the object has ceased burning, is less than eight miles high, and is much closer than the spectacular fireball which may be viewed by residents of a town a hundred miles away. Preliminary sifting and evaluation of mailed-in reports can indicate the area where follow-up interviews should be undertaken. Some reports are fallible, of course; individuals are fallible. But if the best from all the different locations are plotted on a map, there will be found a fair degree of agreement among them, and a very decent conclusion can be reached as to the nature of the object, the location, the height at which it was last seen, the speed at which it approached, the direction from which it came.

On February 26, 1931,1 was visiting in central Kansas when I received a message from Denver that a great meteorite had fallen in daylight in western Kansas. Various press reports received that day and the next put the place of fall in northwest Kansas near Colby; in southwest Kansas; in northern Colorado; in central Colorado; in Nebraska.

Since no accompanying noise was reported except in northwest Kansas and the adjoining state of Nebraska, I was convinced the fall had occurred in that region, though the fireball itself was visible over a territory 400 miles across. I traced it into this area and located the end point. To decide the angle of descent I had either to interview persons fifty to seventy-five miles on either side of the meteor's passage, or by good fortune find an observer who was directly in line with the flight and for whom therefore the ball of fire appeared to stand still in the sky. Thirteen miles north and slightly west of Goodland, Kansas, southwest of Bird City, I found a family who saw only a great ball of fire appear and disappear with practically no motion. This then was the target area, but no meteorites ever were found, or at least none were reported.

A man fifty miles north of Denver—possibly 235 miles from the site of the fall—insisted that this meteorite had landed within a half mile of him. No argument I could advance in correspondence sufficed to convince him that he was mistaken. Finally, recognizing it was possible, though improbable, there had been two meteors about the same time, I drove to this gentleman's home to interview him in person about what he had seen. He took me to an oil derrick where he had been working and he pointed out the exact spot in a neighboring field where he had "seen" this light come to the earth. When I recorded the direction on my instrument, I found it lined up perfectly with my conclusions as to the location of the fall in northwest Kansas—235 miles away.

A second man a mile east reported that the fireball had fallen just east of him. Both these men had seen the same meteor viewed in northwest Kansas.

About seventy miles south of these two, some twenty miles south of Denver, a motorist driving southeast thought he saw a burning airplane drop over a hill just to his left. He reported the disaster at the nearest town, Castle Rock, and townspeople spent the better part of two days searching the hills for a wreck. When I interviewed this man and had him indicate the direction from which he had seen the fireball moving toward earth, it was apparent that he, too, had been looking toward the northwest Kansas area.

A farmer wrote to us insistently that we could collect the meteorite from a field southeast of Holly, Colorado; he had seen it strike between two cottonwood trees only a mile and a half from him.

My personal judgment was that this man had seen the same meteor in northwest Kansas that had fooled the men north of Denver, but on my next trip through Holly I stopped to interview him. He led me out to his yard gate and showed me the little group of cottonwood trees one and one half miles northeast, where he had seen the great fireball vanish, giving rise to a column of smoke. We sighted the instrument; the reading indicated that again we were exactly in line with the northwest Kansas location. The "smoke" was the dust trail left by the meteorite. This dust cloud, which had been seen by all observers, lay at a height of eight to twenty miles and for him its lower end was behind the horizon. He had given me an accurate report as to direction, but he was 150 miles off in his judgment. His was not an uncommon error. A professional astronomer once admitted to me that he had raced off in his car to where the dust trail of a meteor seemed to reach the ground near him. Another astronomer told me how, at the turn of the century, he had chased such a phenomenon on his bicycle; he gave up after twenty miles when witnesses at that distance told just the same story as did those at his home base.

We learned never to decide on the directional path of a fireball until we had interviewed witnesses on at least three sides of the end point or had been fortunate enough to find someone who had seen it pass directly overhead, and we also learned to establish certain units of approximate measurement to aid the descriptions by witnesses on occasions when instruments were not available. Thus we might gauge size and distance against a hand held at arm's length, the width of the palm, thickness of fingers, size of a lead pencil at arm's length, or some other such homely example. Sometimes it was possible to establish very good lines by measuring the distance and height of buildings and trees standing between the viewer and the fireball.

Additional information could be gained if the meteor left a trail, or if a puff of cloud formed. A good way to learn the elevation in degrees of the point where the dust cloud appeared, if there were no instruments available, was to record in feet the height on some building past which the observer looked, and then measure the distance to the building from the observer. Another way was to have the witness draw a line representing the trail of dust with reference to the horizon.

In a restaurant in northwestern Nebraska, I was engaged in a discussion about meteorites with a companion when a third party overheard and volunteered he could tell me "exactly" where I could find one.

As he was leaving town one morning early, he recounted, a tremendous ball of fire came streaming in just over the hill from the south. He said he saw it burn for some time after it struck the top of the hill less than a half mile from him. He would walk with me to the spot. Parts of his story rang a bell. I asked him if he could recall the date of the event. His wife, who so far had sat silently, spoke.

"I can tell you the exact date. It was the day we were going to my sister's birthday party, March 24, last year."

"Was it about five o'clock in the morning?" I asked.

She agreed that was about the right time. The phenomenon her husband had described was the great fireball of March 24, 1933, whose landing place was northeastern New Mexico. This meteor had quit burning at a height of seventeen miles above the earth. Instead of "striking" the top of the hill as the Nebraska couple had believed, the light was simply passing behind it, still at an altitude of some twenty miles from the ground.

When I had passed through the territory of Pasamonte, New Mexico, just a day before the fireball on my errand to gather up the Melrose meteorite, some local citizens accused me of having purposely stationed myself in the vicinity to be present when the thing arrived. Why else would I have been so far away from home and in this particular area?

The Pasamonte fireball produced typical examples of the fright and confusion often associated with the passage of a great meteor.

Sim Cally, a veteran rancher who had spent most of his sixty-five years on the New Mexico and Texas plains, had moved with his men to a new sheep camp the evening before. As usual, he was getting up at five o'clock to start the day when a blinding light and horrible roar startled him. Their camp was in a canyon and when he saw that ball of fire come into view over the canyon wall, he told me he thought the whole earth was burning up.

"I yelled to the boys, 'It's the end of the world! It's all over now!' "

The fireball passed about seventy-five miles from him and at a height of about twenty miles.

Another rancher 200 miles farther from the meteor's course reported that it killed several of his cattle. In reality, their deaths were due to lightning striking the wire fence against which they had huddled during a storm.

Scores of early risers who saw the Pasamonte spectacle picked up odd bits of stone which they had not noticed before and reported finding fragments of the meteorite.

We learned to approximate all our judgments to take into account our dependence on the memories of untrained witnesses, unprepared for the phenomenon they viewed and unprepared to report it.

*Every great scientific truth goes through three stages. First, people say it conflicts with the Bible. Next, they say it had been discovered before. Lastly, they say they always believed it.*

*Louis Agassiz*

# 6. NOT ALL KNOWLEDGE IS IN BOOKS

A century ago cowboys riding the naked plains of what is now Kiowa County, Kansas, came upon occasional heavy black rocks scattered over the buffalo grass. No other stones were to be seen for miles around the treeless plain, almost as level as a floor, with a fine, dark sandy loam under the buffalo grass turf.

These unusual heavy rocks, with their odd dark color, attracted the attention of the cow hands, who took to using them for weight-lifting and shot-put demonstrations. One cowboy, suspecting these heavy stones must have value corresponding to their weight, hid a few in a badger hole. He never found any sale for them, however, and revealed their whereabouts only on his death bed.

When Frank Kimberly brought his bride, Mary, to Brenham in the raw Kansas prairies to homestead at the end of the nineteenth century, the first thing she noticed was not the buffalo grass, nor the sod house, but a rusty looking black rock.

"Frank, do you see that rock? Do you know what it is?"

Of course, he told her, it was a rock.

"Well, it isn't any ordinary rock. It's a meteorite."

And Mary carried it up to the door and kept it. She added more and more of the "iron stones" that were common in the neighborhood, but Frank, and neighbors too, only laughed at her growing rock pile.

After the area was opened for homesteading, the "iron rocks" were accepted as unusual, but useful, objects native to the locality. In an area that otherwise was bare of rocks, the black stones were used as weights for rain barrel covers, corner stones for chicken houses, ballast for dugout roofs, and to hold down fence lines.

It remained for Mary Kimberly to prove they had value beyond their daily uses.

When Mary had been a little girl in Iowa, her school class was escorted by the teacher to the railroad station to view a great meteorite that was being transported to an eastern museum. Mary, a perceptive child, never forgot the experience nor the appearance of the meteorite.

Frank laughed at Mary's belief the stones had come from the sky. He went back to his work. When he plowed he occasionally ran into a hunk of iron rock that crumpled the share point, knocked the plow handles into his ribs and inspired language far more colorful than he was used to employ.

As Frank plowed the meteorites out of the ground, Mary dragged them back to her pile. One day when she brought him his lunch in the field, she saw he had dug out a particularly big one, weighing probably a hundred and fifty pounds. They loaded it onto his wagon, but her young husband, who was becoming increasingly disgusted with Mary's "crazy notion," dumped it out later instead of taking it in from the field.

Mary was not one to let go an idea. She wrote to everybody she could think of who might have knowledge of geology, asking that they examine her collection. Finally, after a five-year campaign of letters, she reached Dr. F. W. Cragen, a geologist at Washburn (Kansas) College, who agreed to look at her iron stones. He was amazed and delighted at her hoard, and on the spot paid her several hundred dollars for the better half of the approximate ton of material she had gathered by that time.

That first big sale price was enough to buy a neighboring farm, and on their new property the Kimberlys found more meteorites to sell. Other scientists followed Dr. Cragen to the "Kansas Meteorite Farm," and the market was brisk for a number of years. Frank took up the cause enthusiastically and would go about the neighborhood offering to buy up the iron stones. He sold for $100 a meteorite he had used to plug a hole in a pig fence. He was not so discerning as Mary, however, and sometimes paid his price for a hunk of slag or a chunk of sulphide from a coal pile. He went back to his field and hunted in vain for the heavy meteorite he had dumped in dudgeon from his wagon. Years later, when he was an old man and Mary an old lady, he told me how he hunted again and again for that stone, but never found it. He would laugh at himself, and boast of Mary's cleverness, and she would sit by, proud and glowing.

Frank had one story of his own acumen that he loved to tell. He said that one of the first of the large meteorites to be found in the area had been taken into Greensburg by a lawyer, a Mr. Davis, and placed on the sidewalk just outside his law office door as a curiosity. This was prior to recognition in the community of the true nature of the heavy stones.

Before Mrs. Kimberly had made her first sale she and Frank had tried to persuade Davis to give Mary that "rock" to add to her collection. He even refused $10 for it. The specimen weighed more than 200 pounds, and after Mary had sold half her hoard to Dr. Cragen, while she and Frank still were keeping the sale secret, Frank took $200 in five-dollar bills and went to town, determined to buy the big stone.

"Mr. Davis, I want to buy that rock. What'll you take for it?"

Davis struck his courtroom pose, cleared his throat importantly and replied in stentorian tones.

"Now, Frank, I don't care particularly about selling that rock. I sort of like it out there, but if you are determined to buy the thing, it's going to cost you $50."

Frank reached for his roll of bills and peeled off ten of them, which he placed in the lawyer's hand. Davis couldn't help seeing the bank roll.

"Damn you! You were prepared to pay me a couple of hundred for it. What's gotten into you, anyway?"

Frank proudly loaded the meteorite into his wagon and drove home. Later he sold it for more than $200.

I developed a great respect and fondness for the Kimberlys, and when writing my first book, *Our Stone-Pelted Planet,* in 1931 and 1932, I paid several visits to their home in Haviland, taking notes for a chapter about them and the "Kansas Meteorite Farm," which naturally was a story mostly about Mary Kimberly. When I told her of this she was delighted and proud, and she looked forward to seeing a copy of the book, which was being published by Houghton-Mifflin.

Bringing out the book took longer than expected. Meanwhile, Mary Kimberly, then in her eighties, was failing noticeably. In early 1933 I received one or more cards in her shaky handwriting inquiring as to when she could see "that book." I assured her the publishers had promised its early arrival. In April of that year I made a lecture trip to the East, and before I left, Addie and I agreed that if the book arrived before my return she should send one immediately to Mrs. Kimberly with a note that I would autograph it later. But the book was too late.

Addie rushed a copy in the mail to Mrs. Kimberly but received in return a letter from Mary's daughter with the news that her mother had passed away six days before.

In our meteorite laboratory in Denver I cut many fine specimens from this Kansas fall, given the name of Brenham, after the nearest post office. It belongs to the unusual pallasite class and is very beautiful, containing greenish crystals called olivine surrounded by bright nickel-iron. The olivine was nearly always fractured and discolored by oxide of iron due to long exposure to weather after arriving on the earth, but in one instance my cut revealed a perfectly beautiful crystal, transparent but of greenish golden hue, which I determined to remove and have mounted in a ring for my wife. Addie never had worn a ring, since before we left Kansas we conformed mostly to the modes of behavior favored by the Church of the Brethren, including the ban on jewelry.

I thought: How romantic, to present a ring with a gem cut *out of this world!* I took the olivine to a jeweler and cautioned him to be most careful with it and directed him to bring me something really beautiful. For a long time he kept telling me that he hadn't got around to it yet and when finally I went to urge him to get it ready for Addie's birthday he told me that in attempting to mount it he had broken it. I've never found another perfect crystal.

The Kimberlys had marketed a ton and a half of meteorites by about the turn of the century and then could find no more buyers. For twenty years nobody seemed to be interested in what they found. In 1923 when I first went to their farm, they still had a number of small meteorites and two large ones that they had not been able to market. I managed to buy them with borrowed money and encouraged the couple to search for more.

These specimens from the "meteorite farm" made a substantial addition to my young collection and were a substantial help to my thin bank roll when I made resales of parts of them. In 1927 I purchased a mass weighing 465 pounds, turned up by a plow boy. Ultimately I added a half ton of Brenham to my collection before the supply seemed to be exhausted.

Soon after publication of my book I gave a lecture in Hutchinson, Kansas, taking along copies of the volume for sale. After my talk a member of the audience, H. O. Stockwell, whom I had met briefly through my brother John some years previously, came forward and purchased a copy, asking me to autograph it.

He recounted to me long afterward that he went home that night, read the book, and became excitedly interested in hunting meteorites, but because of lack of finances to pursue the matter, he laid the book and the interest aside. Some ten years later, in 1947, when he was in better financial shape, he read the book again. Then he set out to equip himself with a metal detector and drove to Kiowa County, where he spent the day combing a field on the old Kimberly place.

Weary and with eyes burning, he decided to quit. As he walked toward his car still carrying his machine he got a clear signal, started digging and unearthed a 750-pound meteorite. That enslaved him. Days and weeks on end he pushed his wheelbarrow-mounted detector until he had covered the neighborhood, with the result that he recovered a total of one and a half tons of the Brenham fall.

More than three and a half tons is known to have been collected, and more probably was picked up but never reported, and undoubtedly some remains unfound.

One day Stockwell read of a meteorite find made in Wisconsin almost a hundred years before in which only two small irons had been picked up only a few rods apart. Playing a hunch, he loaded his machine on top of his car and drove the 1,300 miles to the village of Trenton, Wisconsin. There he arranged with the landowner to search and began sounding the soil. Almost immediately he received a signal indicating the presence of metal and dug out a 450-pound iron. A little more work and a second mass of about the same size was recovered. With these two great specimens he headed back to Kansas.

Various kinds of detecting devices have been used in scouting for meteorites, particularly since the war with the easy availability of military mine detectors, with varying degrees of success in the hands of various persons. Stockwell, who combined his layman's interest with a practical wizardry in the handling of electrical and electronic appliances, must certainly be the most successful dowser for meteorites.

The first meteorite crater recognized by white men in the United States was that one in Arizona previously mentioned. The pit began to be suspected as of meteoritic origin in 1891 but was not given serious consideration as such until 1903. Even then only a few scientists, led by a mining engineer, Daniel Moreau Barringer, were willing to advocate seriously that meteorite craters existed. The scientific world in general rejected the idea, especially after the Barringer group had carried out an extensive and expensive program of exploration in the crater without discovering the great meteorite mass for which they were searching.

At the time of my beginning interest in meteorites in 1923 the general opinion among geologists and astronomers was that the Arizona crater had been produced by a gaseous volcanic explosion, a hypothesis advanced by Dr. G. K. Gilbert of the United States Geological Survey in studies of 1892 and 1896.

The impact explanation was clung to, however, by some persons in addition to the Barringer group, probably by a larger number than so expressed themselves, because to do so would be to label themselves as radicals.

Dr. Merrill had spent some time at the crater and leaned strongly to the meteoritic hypothesis, but his mathematical reasoning and advice convinced him that a meteorite of sufficient size to produce the crater would of necessity explode on impact. Merrill sought in vain for evidence of such an explosion in the form of "volatilization products" and stated in 1908 that their absence constituted "the greatest difficulty in accepting the meteoric hypothesis." Merrill had not moved from this position as late as 1928 nor, so far as I know, at the time of his death in 1929.

Farrington wrote in 1915: "Complete proof of the (meteorite) hypothesis would be obtained by finding within the crater above the undisturbed sandstone a meteoric mass or many of them which would together approximate the size mentioned (500 feet in diameter)."* So far as I know, Farrington had not changed his opinion ten years later.

I did not then believe that a large mass would have to explode on impact. Personally, I shared Barringer's belief that the crater was meteoritic and that he had found the mass of the meteorite by his drillings in the crater.

I reasoned that meteorites of all sizes up to those that were described by astronomers as asteroids must have bombarded the earth occasionally during its long history and that therefore other meteorite craters would be found. In fact, I saw no reason why meteorite craters should not be a prominent feature of the earth's topography except for their concealment or destruction by the forces of erosion and weathering. As I traversed the Kansas plains in search of meteorites during the late twenties and early thirties I sought constantly for evidence of such features as I suspected an ancient crater would present.

In early 1929, visiting Frank and Mary at their Haviland farm, I inquired as usual whether they had found any more meteorites. They had not, but Frank, as he was used to doing, began to reminisce. He was telling about one of the occasions when his plow had struck a meteorite and how profitable the damage to his implement had turned out to be, when Mary interrupted.

"Which one was that?"

"Don't you remember that sixty-eight-pounder that I hit in that old waller?"

I broke in. "Do you mean to tell me that you found one of those meteorites in a buffalo wallow?"

At Frank's affirmative answer I inquired further. Mary said she had picked up "about a bushel of those real small ones" around the wallow, but not in the hole. I asked Frank to show me the wallow. It was on the same quarter with the farmhouse, and we went out to it. I carried along a shovel.

Frank showed me a shallow depression about forty feet across. The feature that attracted my attention was a rim around the edge, rather conspicuous against the otherwise flat landscape. Winter wheat covered both the depressed floor and the elevated rim, but the rimmed depression was plainly evident.

"Can you show me just about where you hit that meteorite?"

Frank pointed to a spot inside the eastern rim. With his permission, I dug a short trench along the inner side of the southeastern rim. When I reached a level below plow depth I began encountering small, potato-sized, rusty brown nodules. Breaking one revealed rounded olivine crys-

***Gilbert in 1891 had hypothesized that //the crater had been produced by a meteorite, that body should have been of the order of 500 feet in diameter.**

tals exactly like those found in the pallasite meteorites that had been found in this and neighboring fields during more than forty years.

Except for the olivine crystals they contained, these rounded rust-colored lumps bore no resemblance to the meteorites that had proven such a boon to the Kimberlys some thirty years before. Frank recognized the significance of the olivine inclusions. He and Mary had found some oxidized specimens on their farm. They never had been able to find a market for them, however, so Frank attached no importance to my find in the wallow.

I was elated at what I had found, but I tried not to show too much interest, thinking it best not to give Frank any reason to get commercial ideas concerning the possible contents of this little depression. He would recognize that the "burnt" specimens, as he called them, had "no value," but I didn't know what he might think of the possibilities in the depths of the bowl if I gave him the idea of a meteorite crater.

I inquired whether he would be willing for me to excavate the wallow and Frank indicated that if anything was to be done he would do it himself. He said they had been trying to fill in the hole during the years of cultivation, that it "used to be a lot deeper" and that in fact it had been quite a water hole for the cattle when the field was a pasture; it had held water for long periods after rains. If he had thought there were meteorites in the hole he would have dug into it himself.

I explained to Frank that more important than any material that might be found in the depression would be the information concerning the manner in which it had been produced, but I did not press the matter of further excavation for fear that he might undertake it himself and ruin an unprecedented opportunity for securing data on the question of meteorite craters. I conceived that these oxidized forms with their shell of oxides containing remnants of a true pallasite might be scientifically more valuable than unoxidized specimens. Besides, I wanted to ascertain the form of the buried crater. If Frank were to do the excavating, I knew he would go after a "big one" and ignore everything else. I secured his promise that I should be present when and if he did any excavating.

Since I had been his only buyer of meteorites since about 1900, Frank Kimberly could see no great urgency about tearing up a bit of his wheat crop merely to satisfy his or my curiosity.

I returned home convinced that I had discovered a meteorite crater. F. G. Hawley, the chemist, verified the meteoritic character of a specimen I sent him for analysis. I wrote a paper for the *McPherson College Bulletin* in which I described briefly the finding of this strange type of oxidized meteorite, which I named *meteorode,* under and inside the rim of the depression in the field, thus placing it on record but withholding the use of the term *meteorite crater,* until I had opportunity to make a proper excavation.

The specimens I had found in the crater looked so much like the ordinary nodular masses known as "iron concretions" that I thought it would be interesting to send some to professional geologists for identification. Accordingly, I sent samples to four leading universities where the subject of geology was prominent in the curriculum, simply requesting that they be identified for me. The answers that came back were unanimous that my specimens were "ordinary concretions."

In 1932 I visited the Odessa, Texas, crater. Finding of this crater had been announced by A. B. Bibbins in 1926, but its meteoritic origin was held in even greater doubt than that of the Arizona crater.

When I saw what others had described as a "peculiar hole" on the high plain within a mile and a half of one of our great national highways (U.S. Route 80), I was thrilled. The great saucer-like depression was almost 600 feet in diameter, with a depth of about eighteen feet and a rim rising some four feet above the level of the plain. I came away from this "questionable" Texas crater with a 300-gram meteorite, a number of smaller ones and with not the slightest doubt as to the crater's true origin.

In 1933 I presented a paper at the annual meeting of the American Association for the Advancement of Science, southwestern division, under the title, "Meteor Craters vs. Steam Blowouts." At the same meeting there was read a paper written by L. J. Spencer of London describing the Henbury meteorite craters of Australia.

By this time it had been four years since my Kansas discovery. I felt I could wait no longer. I hurried home to the Colorado Museum of Natural History and made such a plea to Director Figgins that he agreed to put up the expense money if I could get permission from the landowners and would give my time.

Excavation of the Haviland crater—the first such excavation in the world—perhaps was the most significant event in the history of the Kansas Meteorite Farm.

My son, Bob, then fourteen, was with me. Frank and Mary Kimberly were dead, but the younger generations of Kimberlys, both adults and youngsters, showed an active interest in plans to dig out the old "wallow."

Power machinery was not used as much on Kansas farms in 1933 as it is today. We hired two teams of horses and two old-time road scrapers.

We made several careful cuts, excavating and examining the soil between each operation. The excavated crater was in the form of an elongate bowl. The first cut yielded many meteorites ranging in size from that of grape seeds to as much as fifteen pounds. Each was surrounded by a layer of rust-colored sand or soil about one-fourth to one-half inch thick.

Our method of operation was to remove the crater fill with team and scraper until we began to see the rust stains that marked the meteorite-bearing zone. Then the team stood by and men with hand shovels dug meteorites in about the same way as they might dig potatoes on the farm.

For the most part the specimens ranged in size about the same as a good crop of potatoes with an occasional larger one. At the mid-point of our second cut we uncovered the top of a rounded mass larger than a basketball and right beside it two others almost as large. Several smaller knobs were interspersed in such manner that we supposed they all were merely prominences on a mass some three feet across. Darkness overtook us before we finished uncovering this object and so we went to bed contemplating the big day to follow when we would feast our eyes on a mass of a ton or more.

All of the specimens we were finding in the crater were completely oxidized; moreover some of them were quite moist and had to be handled with great care to prevent their falling to pieces. Consequently, we found it necessary to clean away all dirt from around them before attempting to move them. In the morning we renewed this process with all the patience we could muster. This operation gradually disclosed the disappointment that we were not uncovering one large mass but several smaller ones, nested together. The largest weighed eighty-five pounds. Another was half as large and a third was slightly smaller. There were several lesser ones. Our "ton" had gone the way of many a "big meteorite" hope. When the job was finished we had about 1,200 pounds. Half of this weight was in specimens ranging from ten to eighty-five pounds.

We later searched the Haviland crater area for magnetic nickel-iron particles scattered by the crater-forming explosion. Bob Nininger and Alex Richards dug 1,400 post holes, the removed soil of which was screened and magnetically combed for nickel-iron particles. A considerable scattering of such particles was wrapped. In 1937, using such detecting devices as then were available, we attempted subsoil search for additional meteorites, but had no luck. The first successful work of this nature in that area was that of Stockwell ten years later.

Excavation of the Haviland crater in Kansas increased my interest in the "peculiar hole" at Odessa, Texas. Of all known meteoritic craters on the surface of the earth, the Odessa seemed best adapted for excavation. The Kansas crater—thirty-six by fifty-five feet—was tiny by comparison. The Odessa crater—almost 600 feet in diameter—covered between six and seven acres. Surely the meteorite mass or masses which splashed into the earth to form it must have weighed hundreds and possibly many thousands of tons. I estimated the original depth of the hole at about 180 feet, most of which had been filled in with sediment, supporting a surface not unlike the greasewood dotted plain on the outside.

On an earlier visit in 1932 I had equipped myself with an electro-magnet, with a cord attached to a battery; and with the battery as a hub, I proceeded to comb the surface in a large circle. The electro-magnet was mounted on a long handle, so the procedure was not unlike raking leaves from a lawn. For a couple of days I stuck to my self-appointed task, shedding off* my magnetic gatherings at intervals into a box; and in this way I collected about 1500 fragments. My harvest aggregated about eight pounds of material, with a couple of sizable chunks picked up on the surface. So far as I knew this was the first electro-magnetic rake used in meteorite collecting.

In the fall of 1935 I received financial help from Dean Gillespie and, with Bob accompanying me, went again to Texas. We were armed with an entirely new device, a magnetic balance invented by G. L. Barnett of Oklahoma. He had been working for a number of years to perfect his instrument with two principal objects in mind; to visit old camps on Spanish trails and oW battlefields to hunt for historic relics and to attempt to locate some of the traditional buried treasures of the Southwest.

"If your instrument operates on the principle of magnetics," I told Mr. Barnett, "it ought to be at its best on meteorites—if it works." Mr. Barnett demonstrated its virtues on a stony meteorite, and I borrowed the machine.

There was nothing in sight on the surface when Bob and I arrived at the Odessa crater, and six acres plus is a lot of area to work over with any kind of instrument, but I was conscious of the old thrill of anticipation when we set up Mr. Barnett's balance. Would it work? So much might depend on the answer to that question.

Noon had almost come by the time we had it set up and connected to the battery.

"We won't eat until we find a meteorite," I told Bob.

With a grin, he adjusted the headphones and plugged in the vibrator. Then he began walking about, carrying the awkward gadget with him, while I kept the long cord free from surface obstructions. We had worked for only a few minutes when Bob began moving the machine carefully back and forth over a certain spot. Just as I walked toward him he uttered a disgusted groan and kicked a small tangle of rusty wire away. Ten minutes went by; we were approaching the fifteen-minute mark when Bob stopped.

"Dad, I've got something," he said tensely.

I freed the trailing cord from rocks and bushes and joined him, armed with a probing iron. We moved about cautiously until the instrument was in balance, locating the right spot, and I dug in with the iron. The first prod struck a one-pound meteorite just under the surface.

We ate lunch in elation and haste, eager to continue finding meteorites. That afternoon we located seventeen meteorites in all; then we ate another lunch and made a dry camp in the crater, under the sky.

Long after Bob was asleep, I gazed up at the clear heavens. Ever and anon a meteor would shoot across the starlit vault. Lying there I found myself picturing the great fall that had made the Odessa crater: A huge mass of iron from outer space, streaking across the sky, seen over a distance of a thousand miles or more; a blinding light, going out as suddenly as it had first appeared; thunderous detonations; heat destroying all vegetation within a diameter of fifty, or perhaps a hundred miles; and the mighty splash as the mass hit the ground and ploughed its way far beneath the surface of the plain, sending thousands of tons of rocks and dirt and fragments of itself upwards and outwards to form a rim that survived through millenniums.

I slept at last, but was up at daylight to walk around. I picked up two or three meteorite fragments weighing an ounce or so, and came at last to the northeast section of the rim, where I happened to notice a chip lying partly buried beneath a greasewood bush. I attempted to gather it in, but it wouldn't be picked up. Even with the toe of my boot I could not budge it; finally I dug out a specimen weighing eight and a half pounds, the largest found at the Odessa crater up to that time.

We breakfasted and put the instrument to work again. By this time I regarded Mr. Barnett's invention with profound respect, for each time Bob indicated a spot to dig, the probing iron found a meteorite without any fumbling around. Every hole yielded its specimen. We dug out ten more, for a total of twenty-seven meteorites, aggregating thirty-four pounds, located by Barnett's magnetic balance All were on the rim of the crater, the deepest about seven inches beneath the surface.

This experience was as successful as any I have ever had with any mechanical detector. It was as close to Stockwell's kind of luck as I ever came, lacking his wizadry with instruments.

I came away from the Odessa crater with three convictions:

First, that there must be within the crater tangible masses of metallic meteorites beyond the reach of Barnett's instrument.

Second, I would recommend that the federal government excavate the crater according to the means I had utilized at Haviland, and that a shaft should be sunk for underground exploration. The aim should be to preserve the surface appearance as nearly intact as possible, all excavated dirt being conveyed away from the crater itself.

Third, I was convinced that the crater was of such interest and scientific importance as to deserve the creation of a park to include its environs by the State of Texas, with provision for a museum to offer explanatory exhibits to the public.

My first conviction, that a mass of meteoritic material lay within the depth of the crater, dissolved in later years as I learned more about the nature of impact explosions. My dreams of a careful and thorough excavation and of preservation of the unique geological feature for future generations dissolved also. My recommendations to appropriate officials met with little response and no action, while the crater was, to my belief, desecrated by the nature of crude surgery performed upon it a few years later. They dug holes here and there leaving the excavated rubble right where it was handiest to throw it. There was no trenching to reveal the structure of the crater. Finally, a ten-foot shaft 160 feet deep was sunk at the center of the crater and the rubble piled around it. O.E. Monnig wrote me after he looked at it and said that from now on it is not Odessa Crater, but "Oh desecration!"

2

In 1915 a young Texan sent a small stony meteorite to the National Museum of the Smithsonian Institution. The Texas specimen was received with pleasure, for it represented a new find. Up to that year there had been placed on record only twenty-two stony meteorites over the entire United States that had not been seen to fall. The young man was sent a check and asked to search for additional meteorites. In the course of two years he supplied about a dozen stones, averaging about five pounds each. Then it was concluded that the collecting job was complete; a scientific paper was published describing the find; the books on it were closed.

In 1928 I asked Dr. Merrill about this find at Plainview, Texas, which he had described in 1917. Dignified and scholarly, he gave me the facts, talking to me as a country school teacher might to a first-grader. Then I asked him if there were plans to explore further, and he assured me the job was finished and he judged it good. When I asked if there would be any objection to my trying my hand at a search in the Plainview area, I was assured there would be none, but was offered no encouragement.

For years I was unable to initiate such a search. Always I was so broke that I was forced to plan my expeditions to kill two birds with one stone, or even three or four—that is, search for several meteorites at a cost of time and gasoline for one trip. I did make several indirect efforts, working through residents of the area or visitors to Plainview. In 1931 and 1932 I visited the county surveyor at Plainview and he assured me both times that if there were any meteorites lying about in his county he would have found them, for he had lived there forty-two years and "had been on every square foot of the county."

Finally, in December of 1933, my brother John and I were returning home from a long, fruitless and tiring trip into Mexico to investigate a "fifty-ton meteorite" that had turned out to be an outcropping of iron ore, and a half dozen other stories that had sounded as good and ended as poorly. We neared Plainview about an hour before sundown.

"We will stay here tonight," I told John, "and before we go to bed, we will go out into the country and get a meteorite. We'll sleep better."

John looked at me with real alarm. Was I feeling all right? What was I talking about? Did I know of any meteorite? Had I seen it? Hadn't we just wild-goose-chased a half dozen reports in Mexico? This, the first trip he had taken with me, had proved to be anything but pleasant, as well as luckless. The food had been terrible, the water worse. Fleas, ticks, ants, scorpions and snakes had helped to make our days and nights in Mexico miserable. We had found absolutely nothing, and here we were, three days before Christmas, returning home nearly broke.

But I did have something of a plan to account for my optimism. There was pretty good reason to think it might work, and anyway, I told myself, it is better to think up than to think down. This Plainview prospect never had yielded anything yet, but I was confident it would yield if I made a house-to-house canvass.

We pulled into the first cabin camp we approached at the outskirts of Plainview. We paid for our four walls, with iron bedstead and mattress, and drove into the countryside.

I started rapping on farmers' doors catching the men just back from the fields at dusk, showed them my sample of a stony meteorite and explained I was in the market for similar stones. The first surprised farmer told me he had seen that kind of rock many times, that it was about the only kind of rock around there, but that he never picked up and saved any. I gave him my card and told him I would be back.

At the next place, I got about the same results. At the third farm, the family was new; the farmer remembered seeing nothing like my sample. At the fourth house, the large family and hired help were at the supper table, eating by lamplight. The patriarch of this group greeted me coolly and with some puzzlement. When I felt that impatience was turning into hostility I managed to interject that I would pay for stones like my sample at the rate of one dollar per pound.

The father jumped to his feet, grabbed the lantern and rushed out into the yard, followed by an eight-year-old daughter. In a couple of minutes they were back, bringing an eight-pound meteorite.

"Is this what you are looking for? We've been using it to hold down a chicken coop against the wind."

When I handed him a check, he said he believed he could find more specimens about, but would have to wait for daylight.

Out at the car, I laid the meteorite in my brother's lap. "Let's go back to town and go to bed," I told him.

The next day we continued our survey and by evening had acquired twenty-six meteorites, totaling 152 pounds, paid for with checks I could cover with a note before they reached Denver.

One elderly gentleman listened with considerable curiosity as I explained my mission and displayed my sample; then something seemed to click in his memory.

"Let's go out and look around the barn," he suggested.

From one place to another he searched, finding nothing. Finally he went to the cow shed and from a crossbeam he took a small fist-sized meteorite.

"I've been keeping this around to take after my bull with," he told me. "My bull has a pretty mean disposition but when he goes on a rampage I only need to hit him once with this, somewhere around the head, and he quiets right down."

The old farmer had to find a new method of bull-subduing or a new instrument, for he sold the meteorite to me.

At a well-cultivated farm I received a somewhat stern reception from a generously proportioned woman of middle age who appeared at the back door.

Her hand fixed firmly on the screen door latch, she demanded, "What do you want?"

As affably as possible, I described my purpose. Telling her I was hunting for rocks "like this," I showed her my specimen, said I had reason to think there might be similar stones on her farm, and concluded with the pronouncement that I would pay a "dollar a pound" for them. My hostess' stare grew progressively more cold and threatening until those last magic words. Then her face melted into a thin smile as she seemed to gaze past my head in an effort to recollect something.

Finally, "How long you going to be here?"

"Just long enough to find out if you know of any stones like this," I told her.

"Well, there's some of that kind around here some place. You go look around the garage and I'll go down in the basement."

When I came back from my search she was waiting on the porch with a meteorite in each hand. Each bore a coating of salt a fourth of an inch thick.

"Is this what you want?"

I nodded.

"Well, we've been using these as weights in the pork barrel. That's why they're covered with salt. Wait here. I think there's more."

She brought three more stones. When I paid her for the lot she stared at the check a moment and shook her head.

"You know," she said wonderingly, "that's more than I got off the farm this year."

Crops had been an utter failure in that dust-blown depression year of 1933.

John and I drove into one farmyard that seemed to be unoccupied and decided to have a look around. I walked out to the windmill and the adjacent milk house. In the dry milk trough lay a four-pound meteorite that probably had been used as a weight on a milk crock cover. Three more stones had been thrown at the foot of an old apple tree in the small grown-over orchard. Another lay by one of the windmill legs. At the next house, where we were able to purchase several meteorites, we asked about the vacant place.

"That belongs to Dean Huff, but he lives in town. There's nobody living there now."

I said that we had walked about the place and had picked up some meteorites; now we wished to settle for them. It was the farmer's recommendation that we just take them along and not bother, but he told us how to reach the farm's owner.

That evening I rang Dean Huff's doorbell. He looked rather skeptical as I stood there with an armful of rocks. When he asked what he could do for me, I replied that I thought we could do things for each other. I had gathered these rocks on his farm, I explained, and had come to settle for them.

"Well, I reckon you are welcome to any rock you find on my place."

When I told him I had paid his neighbors for similar stones, he invited me into the house.

"These are meteorites," I told him as I put down my burden, "fcegally of course these five stones belong to you, but I don't imagine you have much use for them. They contain nothing of value except information, but since meteorites are the only objects from outside the earth that man can touch, it is important that they be studied. That is my reason for wishing to buy them."

"What do you pay for them?"

I told him I was paying a dollar a pound to induce the farmers to watch for and preserve meteorites. He asked a series of questions.

I wrote him a check for $28. We had been talking at the foot of a long flight of stairs leading to the upper floor of the rather pretentious, old-fashioned, high-ceilinged house. I had assumed we were alone, but no sooner was the check handed over than there came a feminine voice from up the stairwell:

"Now I know where we get the money for that Christmas dress!"

Mrs. Huff came bounding downstairs then, young and beautiful—I'm sure we helped her get her wished-for dress in time for Christmas.

With two days now between us and Christmas Day, John and I headed northward, feeling a touch of Santa Claus glow after our weeks of bad luck. On the way we stopped at the Pasamonte ranch and obtained the first specimen from that fireball chase, then nine months old.

The brief stopover at Plainview was the beginning of a campaign of search that yielded 900 meteorites by 1948 in an area about sixteen miles long by four miles wide. There are doubtless other meteorites to be found there yet.

We always re-checked carefully each specimen recovered on a field trip. We were aware of the possibility of two falls occurring in the same area over a period of a thousand years and of the fact that even stony meteorites of the sturdier types may survive as long as a thousand years or longer. There always was a chance that two strewn fields might overlap.

Because we wanted to determine the bounds of the actual Plainview field we would sometimes extend our canvass to farmhouses just outside the area known to have yielded meteorites. On one such survey I had driven along the western edge of the producing area and then turned east on a line about two miles south of the recognized field. I found nothing and was speeding up on my way to Hale Center, a village about three miles south of the proven field, when I noticed a large rock garden in front of a house set back several rods from the road. I stopped, backed the car, parked beside the road, scanned the rock garden and then rapped on the house door.

A pleasant lady asked my errand. I apologized for bothering her, and picked up a dark-brown six- or seven-pound stone.

"Why that's the ugliest one in the whole lot!"

"Yes, I know, can you tell me where it was picked up?"

She replied promptly that she had found it over near Abernathy, a village about eighteen miles away.

When I explained that it was a meteorite and so was important for scientific purposes she wanted to give it to me, but I insisted on her accepting the dollar a pound that I had paid for others in the area. Leaving her puzzled but pleased, I went on my way.

At least three and probably four different falls were recognized in the crop of meteorites that we harvested in the Plainview area that had been "finished" decades before.

3

The discovery of new meteorites carried a bit of glamour in the minds of many persons. Offers to participate in my quests came rather frequently from friends who had been keeping an eye on my adventures. Actually, of course, my efforts often seemed more successful as viewed from the sidelines than as seen through the eyes of a man who had money invested in them. Though often a project fell flat, the usual outcome was that my backer or "Cooperator" took the disappointment philosophically and waited for another opportunity to come along which might be luckier for both of us.

Meteorite finds have been more rare than discoveries of comets in the sky. Consequently any new meteorite find was an event considered newsworthy, but the many fruitless efforts that plagued our days were not so well known. We never made any effort to keep them secret, but the newsmen did not see them as worthy of type space, nor was I anxious to have the failure publicized.

I always warned "investors" that there might be no visible results from our effort. Generally the proposition was that they would furnish the cash outlay and I would give my time and knowledge, any discovery to be shared fifty-fifty.

*Tektites with author and Addie.*

*Dr. Nininger's basement study in Denver.*

The Colorado Museum of Natural History acquired quite a number of important additions to the museum collection through such support of a number of field efforts. A number of individuals shared projects. There were others besides those already mentioned. They included Arthur Thompson, a good friend who was keenly interested in my program and supported minor excursions at different times, sometimes accompanying me; W. F. Wasson, a Denver attorney; and Frank Clay Cross, also of Denver.

Frank Cross introduced himself to me in the thirties as a writer in search of a story. His first story about meteorites was followed by others. He wrote for several of the nation's leading magazines and his stories sold so well that I told him one time that he was making a better living out of me than I was out of meteorites! Finally he started issuing what he hoped would become an established periodical which he entitled *The Explorer's Club.* This little bulletin featured various phases of natural history with special emphasis on meteorites. A small fee was charged for membership in the "club" and covered a subscription to the bulletin. The instructions carried therein about recognition of meteorites in the field and the news tips on places for search brought to light several new meteorites. This venture might have proved a real success, but Frank was unable to finance it for very long.

The little Enon, Ohio, stony meteorite might have been lost to science but for one of Frank Cross' articles. An Ohio farmer had found the stone, about a pound and one-half in weight, in 1883. Because it was unusually heavy for its size, he saved it among his various curiosities for the next fifty-five years, residing meanwhile in the various states of Ohio, Wyoming, Washington and Colorado. He had never submitted it to anyone for identification until he read one of Frank's stories.

It was a decidedly mixed blessing that newsmen saw in meteorites a source of eye-catching news. Publicity now is regarded as a necessary part of the launching of any new project in science; but forty years ago publicity was frowned upon by scientists, and any scientist whose name appeared often in headlines was regarded as something less than truly scientific; he was deemed a publicity seeker. I recognized the peril in press reports of my escapades "chasing meteors," but how else could I gather the reports that were absolutely necessary to the work I had undertaken? I was really after meteorites, not headlines.

Eventually I came to agree with David Dietz of *The Cleveland Plain Dealer* that the trouble lay as much with scientists as with newsmen, and that the two were necessary to each other. David Dietz was one of the leaders in establishing a corps of reliable science writers and he was among those helpful to me and interested in my program. The late Ernie Pyle featured my work in his columns. The broad readership of his writings inspired a good deal of correspondence and sending of samples. The local Denver writers who were most interested and helpful included Alexis

McKinney, Roscoe Fleming, and Gene Lindberg of *The Denver Post;* the late Lee Casey of *The Rocky Mountain News;* Frank Conly, a free-lance magazine writer, and, of course, Frank Cross.

I was not quite sure there was not a thorn in the publicity bouquet when my friend and fellow professor, E.L. Craik of McPherson, who had been with me to witness the 1923 fireball, wrote: "Congratulations! I see you made the same front page as Floyd Dillinger." The latter at that time was Public Enemy Number One. But I could not avoid some feelings of pride years later when public attention came from such publications as *Literary Digest, Life* magazine and *The Saturday Evening Post.*

One day in Denver in 1934 I was called to the telephone.

"Hello? Is this Professor Nininger? I hope you'll pardon me for bothering you. I'm Herbert Fales. I'm out at the airport and . . ."

"What did you say the name is?"

"Fales, Herbert G. Fales, from New York. You don't know me, but Lewin Barringer suggested I should get in touch with you. I fly my own plane, and last winter while I was flying over the Carolinas on the way to Florida I saw extensive areas of elliptical scars. When I told Barringer about them, he said you are devoting your life to meteorites and I should talk with you. I wonder if you would like to have me come out next summer and fly over the plains in search of some meteorite craters."

"Wait a minute," I said. "Do you know who you are talking to? I hope you are serious. You are liable to get yourself into a job for the rest of your life."

And that is the way I first heard of Herbert G. Fales, Vice President of International Nickel Company, who has had an important part in whatever contribution I have made to the science of meteoritics.

When I learned that Fales was with the International Nickel Company, I told him I believed the Sudbury Basin in Ontario was caused by meteorite impact and I wanted to obtain aerial photos or fly over the Basin with him. That was in the summer of 1934 and for years the geologists did not accept the impact theory.

Subsequently, Robert S. Dietz had observed that rocks around meteorite craters are distorted by pressure. He called them "shattercones." In 1961 he visited Sudbury Basin and found many shattercones. Later Bevan French made a thorough geological study of Sudbury Basin where he found shock effect in the minerals there. Geologists now accept the meteorite theory and say that the Sudbury Basin is an astrobleme, an ancient impact scar produced by a large meteorite.

Fales did come out to Denver the next summer, accompanied by his bride of a few months, who proved to be a very good sport as her husband piloted us about, dipping, circling and dodging to inspect many depressions in the hope some of them would display tell-tale features that would justify further ground investigation. The late Otto Roach of Denver, one of the West's fine photographers, accompanied us, proficiently recording our study on film.

The first reconnoitering trip occupied three days and embraced a journey of 2000 miles over parts of Colorado, New Mexico and Texas. The plains country, largely uncultivated, seemed to offer the greatest opportunities for discovery of significant features. We thought that we might recognize craters and scars that had retained most of their original characteristics despite passage of centuries, undisturbed except by surface erosion. We photographed numbers of buffalo wallows and prairie lakes.

Over Texas, we flew back and forth for some time before we identified the Odessa crater, which is located in the midst of an expansive plain dotted by hundreds of playa lakes that are dry most of the time. Herbert was alone in the cockpit and the other three of us, in the cabin, were busily scanning the landscape when finally I spotted the crater and penciled a bulletin that was passed to the pilot. Immediately our Lockheed Vega turned sharply and went into a complicated pattern of circling, ascending, swinging and dipping over and back, round and round while Roach snapped his shutter repeatedly, Otto Roach secured what is to my mind the only truly serviceable photograph of Odessa ever obtained.

Two years later Herbert Fales flew again to Denver, and a friend, Chester Lee, and I went with him on a reconnaisance flight, our third passenger this time being Dr. Alfred M. Bailey, newly appointed director of the Colorado Museum of Natural History. We flew across southern Colorado and northern New Mexico to the famous Arizona crater. We circled this great bowl several times, then landed in Winslow, Arizona, to make a ground visit.

That night we spent at *La Posada,* the Fred Harvey hotel in Winslow. The heat was terrible and our discomfort was not mitigated by the constant puffing back and forth beneath our window of an old coal-burning switch engine. At breakfast, when I asked Herbert how he had slept, he replied that he thought he had not slept at all.

Herbert Fales' interest in meteorites was not an evanescent thing, but grew from his training and experience in metallurgy. He set out to secure representatives of as many of the different varieties of meteorites as possible, and built an exceptionally fine collection.

Through the years, on occasions when times were unusually tough for Addie and me, I would look through our stock, pick out an especially desirable specimen and write to Fales, offering it for his collection. Invariably he would buy it. He was one of three or four eager collectors whom I always could count upon for the price of a specimen in an emergency. Each of these collectors presently owns certain meteorites which I never would have let go except that necessity demanded it. Always I could console myself that these specimens would be in good hands.

In the middle thirties I first met Oscar E. Monnig of Fort Worth, Texas. We had corresponded as early as the late twenties. Oscar asked me if the "Nininger method" of discovering meteorites was secret. He reminded me that he had been interested in meteorites almost as long as I had and yet, he said, he had "never found a meteorite larger than could be accommodated in an ordinary desk drawer." We worked cooperatively on numerous occasions. As the years passed Oscar's collection filled many a desk drawer, or comparable receptacle, and several specimens had to be furnished larger quarters.

When he was quite a young man Oscar Monnig initiated a little bulletin, *The Texas Observer,* recording observations in astronomy and meteoritics. He was soon on the way to becoming an avid collector of meteorites. At the same time that he achieved business success in a very busy life as president of a large dry goods company, he contributed notably to meteoritics.

The success of our search for meteorites always depended upon the effectiveness of our message to school children and to farmers. But aside from the search for meteorites there was the challenge of presenting to scientists facts and opinions concerning the importance of meteorites in the history and development of our planet.

Over the years I delivered hundreds of lectures throughout the nation in colleges and universities, in addition to the talks without number given before classes and assemblies in elementary and secondary schools, and the other hundreds of addresses before miscellaneous groups and institutions.

Although I have no complete file of this lecture activity I have been able to reconstruct a list of 182 colleges and universities where I spoke. Included on the list are many of the great educational institutions of our land. At some of these, I spoke several times. I spoke on street corners, in country schools, in the Carnegie Music Hall of Pittsburgh.

Many lecture engagements were made possible by the arrangement for dual-purpose travel I had worked out with Dean Gillespie for pickup and delivery of trucks. There were occasions when my only opportunity to attend a scientific meeting depended upon this combination of labor and culture, and by notifying schools and institutions of my coming visit to their city I often was able to pick up a number of "extra" lecture engagements, with honorariums of $25 or $50. Besides such miscellaneous appointments, there were more formally scheduled lecture tours, arranged in advance to cover a large area and a fairly long period. On some occasions after the children had reached college age, or were otherwise looked after, Addie would accompany me, and we would travel to the east or west coast with a trailer adapted to use as mobile home and laboratory. But sometimes I drove on these tours alone, or traveled by train.

On one occasion after I had lectured before a Harvard geological group, then stood through an hour of questions, I took hurried refuge in my hotel room, getting into bed at once with symptoms of a heavy cold coming on. Almost immediately there came a knock at the door, and I arose to admit a member of the geology staff who had come to deliver mail that had arrived in care of the department. He apologetically asked some more questions and then had a final comment before departing thirty minutes later.

"I have taught in Harvard twenty-five years," he told me, "and I never thought there was as much to be learned from meteorites as I learned tonight."

Such praise helped to counterbalance the judgments of those who so often viewed me as a "mere collector" of meteorites. It was always a source of some chagrin to me to be introduced, as I was frequently, as "the man who has found more meteorites than any other man in history."

Such a statement missed the main point of my life. Collecting occupied much of my time and effort, but collecting served as a sort of platform or footing on which to stand while I sought to educate, and while I pleaded constantly for an organized program of meteoritical research.

Dr. Harlow Shapley of the Department of Astronomy at Harvard always supplied inspiration when I lectured at that great old university. The sense of humor of this famed and respected astronomer sometimes came to my rescue. On one occasion I spoke at some length of the importance of meteoritic dust clouds, deploring the fact that nothing ever seemed to be done about them beyond pure speculation. I exhibited photographs of the dust clouds of the great meteor of March 24, 1933, and also that remarkable, almost unbelievable film record of the fireball itself caught by Charles M. Brown.

One of the young Harvard astronomers rose to describe a remarkable daylight meteor that had been witnessed by members of a Harvard solar eclipse expedition. He told how members of the expedition had just unloaded their equipment to be set up the next day when suddenly a huge fireball swept down the western sky, leaving in its wake a long cloud-like streak which hung in the evening sky for some twenty minutes. He described how this trail lay at first in a straight line, then became warped and twisted and widened into a bunchy sort of cloud.

Dr. Shapley spoke. "How did it sound, Nininger? A little amateurish?"

His question gave me precisely the opening needed.

"I was just thinking, Dr. Shapley, what a pity that our astronomers are not trained to take advantage of such events the way some of our western cowboys do!"

Probably no other great fireball ever was witnessed by so many trained astronomers, surrounded by an unmatched collection of photographic equipment.

On my eastern lecture tours it was my custom to detour through Rochester, New York, and look over the stock of meteorites at the Ward Natural Science Establishment. If there was something I needed for my collection perhaps some of my duplicate specimens could be exchanged for it, or sometimes Ward's would buy an item from me. •

On one of these visits in the early thirties the late Dr. George L. English opened a drawer full of small unlabeled specimens that had been recovered from the rubble of a recent fire and remained unidentified. He said that if I could identify any of these odd pieces I was welcome to help myself.

I recognized a few common things and then came to a small triangular corner piece of a nickel iron meteorite showing untarnished fusion crust on one side and a polished cut surface with a structure I recognized immediately.

Holding up the thumb-sized piece for Dr. English to see, I said, "Here is one that I don't think you want to give me."

"Yes, anything you find in there is yours. Do you recognize it?"

Quite sure that the corner represented a specimen I had never yet felt I could afford to purchase, I suggested to Dr. English that he bring out copies of old catalogs. Meanwhile I weighed the specimen.

"Now," I said, "look for a listing of a 26-gram piece of Braunau, a corner piece with crust."

Sure enough, there was a listing of the scrap, even to a description of its exact shape, quoting a price of $26.

Dr. English seemed quite taken aback, but he still insisted that since he had told me to take what I wanted I should take it along; however, he wanted to know how I had recognized it.

I explained that the untarnished crust told me it was very likely a witnessed fall, since the surface had not had opportunity to deteriorate. The etched surface showed the specimen was a hexahedrite and the only hexahedral iron of witnessed fall I knew of that had never been put on the market was this one that had fallen through a house in Bohemia in 1847. The Branau meteorite had narrowly missed striking two children who were sleeping in the room it passed through. Because of this unusual circumstance it was regarded as very precious and only a small amount had ever been placed for sale. The price was $1 a gram, a high price for a meteorite in the thirties. I was most happy to add this piece to my collection, but I refused to accept it without making payment by way of an exchange.

On another occasion I went to Ward's hoping to sell a five-pound stony meteorite, one of several recovered from a newly discovered fall. Dr. English explained that funds were short just then and suggested I look over their stock and find something I wanted in exchange. I looked about, but there was only one thing I needed, and it was a large slice priced at

$330, entirely too much to trade for the stone I was offering. I didn't even mention it, saying there seemed to be nothing suitable for an exchange and I supposed we could not make a deal.

Dr. English leaned back in his swivel chair, smiled rather mischievously and said, "I have a piece down in the basement I'll give you for it. It's a great big thing and I don't think it is Canyon Diablo, but none of us know what it is since its label was lost years ago."

Of course he knew that I was not in the market for Canyon Diablo, the most available of all meteorites.

"Well, I'll go down and have a look at it."

We went downstairs and there was a half of a large iron. The shape of its cut surface told me at once that it probably was the very mass from which the $330 slice I coveted had been cut, although the 200-pound hunk was so badly rusted I could not be absolutely sure.

"I'll take a chance on it and accept your offer."

Almost before I finished speaking my host called to his helper at the far end of the room.

"Ambrose, crate this big chunk and ship it to Nininger's laboratory in Denver."

Evidently he feared I might change my mind. Before they crated it I borrowed a hack saw and cut off a very small corner which I polished and etched on the spot. When I finished Dr. English asked me if I was satisfied. I assured him that I was.

"Do you mind telling me what it is?"

When I told him it was St. Genevieve, a prize item from St. Genevieve County, Missouri, he was clearly quite shocked. Apparently the shock deepened after the shipment was made, for he wrote me that he had been reconsidering and he wondered if I would be willing to trade back. My answer was to the effect that I would not consider trading back, reminding him that he knew well from experience that had he asked me to identify that mass for him I would have done so gladly without charge; but instead he had approached me in horse-trader fashion and I had accepted his proposition. However, I cut a large slice from the mass, polished and etched it and sent it to him with my compliments. We sold several other slices of the beautiful St. Genevieve meteorite; then the remaining mass became one of the prize specimens of our collection.

Frequently the lecture trips were grueling, particularly those I made alone by train. But they extended both the collecting and the educational phases of my program, and they aided the family budget.

At a little village school in Marsland, Nebraska, I addressed about eighty pupils of the fourth to eighth grades, describing what a meteorite might look like if one should happen to come across one in a field of this farming country. To help the youngsters visualize such a find I said that meteorites are about the color of rusty iron, appearing to have dents in them. They might look, I said, like an old battered, rusty tin can, but of course would be very heavy. A little red-headed sixth grader with a freckled face put up his hand.

"Did you say they look sort of like an old rusty, battered tin can and are awful heavy? I'll bet Dad and I found one when we were building fence."

After school was out the principal and I went home with this boy and found he had a ten-pound meteorite, now known in collections as the Marsland meteorite.

In meteorite hunting I had several methods of operation. When I tired of one because it was unproductive I did not decide it was no good; but I would turn to another task for awhile. If lecturing two or three times a day with no visible results was about to get me down, I'd turn to another method—visiting country editors, perhaps, or talking with farmers on the streets of a small town, or with prospectors in a bar or pool hall. Armed with a couple of small meteorites to gain attention, it seldom was necessary to say much before someone began asking questions. Within minutes half of the men within earshot would be gathered round, and sometimes very important leads came from casual encounters.

If the program had been routine, just doing over and over the same sort of work day after day, it would have floundered in a short time, for I am not a routine man. I doubt if any man was ever less fitted by disposition to be one. If my job required that I climb a certain hill from a given starting point to a particular destination every day I would do it faithfully as long as I held the job; but I probably would find a dozen different routes by which to make the climb.

One day in western Kansas my work with schools had become rather disappointing because the particular district in which I was working had adopted a rule against any teacher tolerating interruption by persons not specifically authorized by the board of education. As I drove along I noticed a number of cars parked at a farm house and guessed correctly that this was a public sale or auction. I stopped.

Fortunately, the auction had not begun yet but everything was in readiness. I approached the clerk of the auction and was escorted to the auctioneer. I briefly explained my purpose, promising not to use more than three minutes of their time, and showed the auctioneer and clerk a few specimens. Both officials were pleased to have a surprise to offer a crowd used to waiting through unvarying preliminaries at sale after sale, year after year. I was given five minutes to speak. The officials and the audience became so interested that I could have talked much longer, but I kept my personal rule never to exceed time allowed. Out of that crowd came a very good lead.

The viewing of a great fireball can be both earth-shaking and wit-shaking. It is an experience long remembered, both the scene itself and the old emotion often being retained with clarity. During my very earliest meteorite hunting in Kansas, I came upon an old man who held vivid memories of the Modoc shower in Scott county of that state in 1905.

"Tell me," I said, "just where were you the night of the great shower of stones."

The old farmer sucked at his smokeless pipe, cupping his horny hands over it with a lighted match. He drew a few hearty puffs, spat at the discarded match stem. Then, resting his hand on the corner of the wagon box and pushing his slouch hat to the back of his head he gazed into memory.

"I was driving 'long that road going north. It was this very wagon. Different team, though. I reckon it was about nine o'clock in the even, clear as a bell—not a cloud in the sky and no moon. All of a sudden everything got light as day and I saw a fire as big as a haystack in the western sky! The team went down on their knees. I thought the world was coming to an end. Before I had time to think about anything except the horses the whole blazing mass busted, looked like a million stars coming right down on us. I looked round at my son, about sixteen, in the back end of the wagon box, and he was down on his knees praying. That's just how it was, and then came the noise—louder than thunder. It boomed and roared and rolled way to the west. I was so busy holding the team I can't say how long it lasted. A few days later the neighbors brought me some funny rocks, all blacked over; but inside, if we chipped off a corner, they were gray like cement. I reckon about a hundred were found in the neighborhood.

"Now you tell me, young feller, did those rocks come out of that fire? And where do you reckon they came from?"

I told him we still were trying to answer that last question, and that was why I was there asking him questions.

"But you can rest assured," I said, "that those stones, that same evening at sundown, were farther away from the earth than the moon is tonight."

# 7. NOT ALL THE BIG ONES GET AWAY

In 1909, in his *Catalogue* Dr. Oliver C. Farrington recognized 247 North American falls, sixty of which had been witnessed and the remainder were merely found and recognized without any data as to time of fall. Of the sixty witnessed falls fifty-six were of the stony varieties, three were irons and one was a stony-iron—twenty times as many stones as irons were seen to fall, while fifty-two times as many irons as stones had been found.

Dr. Farrington puzzled over the fact that certain large cultivated areas like the state of Illinois had never turned up a single meteorite, while Kansas had yielded fifteen, all save one being stones or stony-irons. Nebraska, adjoining Kansas on the north, had yielded six irons previous to 1909 and not a single stone, while to the south the great level plains of the Texas and Oklahoma panhandles had yielded neither stones nor irons. Dr. Farrington also called attention to marked concentration of stony meteorites of undated fall in western Kansas and in the coastal plain of Texas.

Various ingenious speculations were advanced to account for the apparent non-random geographic distribution of falls—obstruction by mountain ranges, abnormally high localized gravitation.

Dr. Farrington offered the suggestion that the soil of these areas was favorable to the finding of meteorites because of the relative scarcity of terrestrial rocks. He also pointed out that dry climate favored preservation for a longer time. At the time of his writing only twenty stony meteorites of unwitnessed fall had been recorded for all of North America.

In 1925 I suggested what I considered to be a third reason to account for the rich yield of Kansas meteorites, an explanation I termed the *interest factor.* By 1929, when the Covert meteorite was discovered as a direct result of my lecture program, I was convinced that one part of the earth's surface was just as likely to receive meteoritic falls as another, and that the education of the public as to the importance and value of meteorites would prove the largest factor in the discovery of meteorites.

It seemed to be that not only must it be due to failure of recognition that more meteorites were not found in more places, but also that the same answer must apply to the discrepancy in numbers of stones and irons: if few meteorites of any kind were recovered due to lack of knowledge about them, then it was natural to expect that still fewer of the stony variety would be found, since they differed less from ordinary terrestrial rocks.

A chief objective of our initial program was to discover stony meteorites of unwitnessed fall.

The task of teaching the people of the plains to know meteorites, to distinguish them from other rocks, had seemed formidable, but not nearly so formidable in our thinking as it actually proved to be in fact.

Opportunity came to speak before scientists as well as laymen. It soon became apparent that it wasn't only the plainsmen who needed instruction: The scientists were just about as ignorant of the nature of meteorites. In certain states where we conducted field work there could not be found a man who could be relied upon to recognize a meteorite if it were brought to him.

But the *interest factor* operated in our favor wherever enough instruction could be given to create an active interest in "keeping on the lookout" for possible meteorites.

The people of the state of Kansas have been credited with being "meteorite-minded" since 1890, but Mary Kimberly had collected heavy black "rocks" on her Kansas farm for five years before she succeeded in attracting the attention of scientists to them, aided by the interest aroused by the great Farmington fall in Washington County, Kansas, in 1890.

At the time of the Farmington fall, and after recognition of Mary Kimberly's meteorites, Kansas experienced a classic example of what I have observed to be a tendency of meteorite finds to group themselves in the wake of some outstanding meteoric event or discovery. During the next eight years another ten finds were made in as many localities, four of these meteorites having been in the hands of their finders for years unreported.

After subsidence of the casual publicity given by Kansas newspapers to the various discoveries of the nineties, finds in the state where scarce between 1898 and 1923, and, except for the witnessed Modoc fall of 1905, little was heard of meteorites. There was a complete gap from 1906 to 1923, except for the Cullison stone plowed up in 1911.

It is my opinion that far less than one per cent of Kansans were meteorite-conscious previous to 1924, and less than ten per cent of the farm population even twenty-five years later. By "meteorite conscious" I mean a degree of awareness that would lead a finder to consider inquiring as to the nature of an unfamiliar stone.

Beginning in 1924, I believe that by our efforts Kansas did begin to become meteorite-minded. It required hundreds of free lectures to many thousands of students, farmers, and farm wives to bring about the thirty-four actually verified finds in the state which resulted from our program during the years 1923-1948.

Our research program depended heavily on the interest and cooperation of schools and their pupils. Any man who offers himself as a target for queries from a group of high school or college students is bound to learn something.

Gradually I had come to realize that the world of science was only mildly interested in that aspect of the universe that monopolized my thinking. Educators presented a slightly different problem: Once exposed to the subject of my endeavors, they became enthusiastic, and would cooperate in any way possible, but there was one fly in this ointment; their enthusiasm was likely to be short-lived.

The high school principal or teacher is so laden with curricular duties and daily reports that any extra-curricular activity can enjoy no more than evanescent welcome into the whirl of the daily grind. Had there been ways to build meteorite hunting into team sport, with development of keen competition among schools, this might not have been so.

For years I have been carrying on a sort of single-minded argument with educators concerning the manner in which introductory courses in geology are presented. In many institutions the subject of general geology is handled primarily as preparatory to more advanced geological study rather than as a course with a character of its own, designed to help fit the average student for greater enjoyment in life. The college graduate whose transcript includes credits for geology often finds himself somewhat helpless to interpret the most elemental aspects of his geological environment. He perhaps has learned the names of a given number of rocks and minerals which made up the study collection of the department, and has learned something of the various formations, all in proper succession as listed by the stratigraphers, but his acquaintance fails to extend to ability to identify these in the field.

It seemed inconsistent that meteorites were deemed unworthy of attention while care was taken to see that general geology students, most of whom certainly would not become paleontologists, were given sufficient instruction to enable them to recognize that a *fossil* is a *fossil,* and to identify several of the more common species. Much attention was devoted to glacial erratics; every geology student was expected to be familiar with traces of continental or local shifting of surface rocks; cosmic craters, however, were seldom so much as mentioned in geological texts.

Despite my argument that it is just as ridiculous to graduate a geology major without equipping him to recognize a meteorite in the field as it is to turn him out without the ability to recognize that a fossil bone is of organic origin, the fact remained that ninety-five per cent of the geologists that I met admitted that they could not distinguish meteorites from certain common rocks and they did not even try. They indicated that they did not think the subject important enough to bother about. A goodly percentage could with more or less certainty recognize a metallic specimen, but many did not even realize that stony meteorites existed.

Our field work procedures became ever more productive, and as broader areas were reached by lecture and survey, the ramifications of initial contacts began to yield results.

We were continuing our original procedure of school lectures, leaflet distribution and press stories. We encouraged the rural population to make simple field tests to distinguish meteorites from terrestrial rocks, offering to buy meteorites as an inducement. Lectures in a given community included illustration by samples of the types of terrestrial rocks most commonly found in the area, together with warnings as to the particular kinds that in the respective locality might most likely be confused with meteorites.

This was the general search. Wherever this initial effort resulted in the discovery of an unrecorded fall an intensive search then was conducted, involving a house-to-house canvass and in some cases personal field work by a member of our "staff."

Our staff, for all practical purposes, consisted of myself; Addie; our son, Bob, as he grew older; Alex Richards and his wife, who took on random assignments to cover some specific area of more or less extent, and for a more or less extended period of time; and incidental arrangements for individuals to perform field work when occasion demanded.

I soon learned that "meteorite-mindedness" was not sufficient in itself. About four out of five of the individuals who were alerted by the lecture and press program would let their interest die on the vine instead of acting on it. A plowman would turn up what seemed to be the kind of stone I had "lectured about that night in the schoolhouse." He would lay it out under the fence at the edge of the field, intending to send it in or to write me; but he wouldn't get around to it—too busy during the day, too tired at night. And, anyway, he had heard that wise old merchant in town say that all this talk about "meters" was bunk for he had never heard about it in the university.

Only when we made repeated visits to the same community would most of the finds be reported. Naturally, many communities never were revisited, or not often enough.

In one area where a large meteorite shower had occurred we collected about three hundred stones aggregating about eight hundred pounds from approximately ten square miles of level farm land—but it took us four years to accomplish this task after our initial discovery, and that first find itself occurred only after we had made four different and unsuccessful efforts to find meteorites in that vicinity.

This sort of experience taught us very early the importance of follow-up searches. Sometimes we found additional meteoritic matter aggregating many times the amount of material gathered at the time the fall was reported and recovery efforts were made and "completed."

Two main facts were impressed on us during the early years of our survey: There was an enormous inconsistency between the amount of meteoritic matter actually collectable in a given area and the extremely small amount formerly recorded for the same area; and even in regions where the amount finally collected was surprisingly large it could be gathered only with extreme difficulty. We came to be convinced that probably no search could ever be made to approach completeness. Our results indicated that enormous quantities of meteorites escape notice entirely, due to the obvious difficulties of conducting any kind of intensive search over any great amount of area where some likelihood of success has not been indicated due to a find already reported in the area.

In many cases the intensive work done in a given area in search of meteorites of a particular fall, however, produced discovery of meteorites of unrelated falls.

Our efforts proved most successful in regions where the native sod had been broken out by the generation yet living, perhaps with the old walking plow, and in regions where the soil is relatively free from terrestrial rocks and dense growths of vegetation. Since a reasonable density of population proved to be desirable, along with the cultivation of the soil, our methods showed their greatest success in limited areas—prairie farmlands and southwest range lands.

Our strategy was devised too late to be applied effectively in many areas of the earth's surface. Enlightenment of the populace, of course, remains a key factor anywhere, and, ultimately, new technological developments of civilization will have to be utilized to make up for opportunities lost in some areas by that encroaching civilization.

## 2

It seemed only necessary for a rock to be found out of its regular association for it to become a meteorite in the minds of many laymen. Absence of other similar rocks in the immediate vicinity seemed proof enough that it must be a meteorite which had fallen from the sky.

So our mail would bulge with samples sent to our home laboratory for inspection—of 2,000 of these only two were meteorites. The whole great conglomeration represented the best efforts of many persons to put into practical use the information I had endeavored to give them. The ratio of meteorites among specimens submitted by persons who had heard a lecture or been contacted personally was much better—one meteorite out of twenty-five or fifty submissions.

Sometimes we were faced with real riddles of masses of iron or stone which in convincing ways showed characteristics of meteoritic origin and yet could not qualify for positive identification. Sometimes there seemed to be no logical explanation for the presence of such masses.

Again and again from the northwest there came samples of what appeared to be slag iron but which the senders insisted could not possibly have come by human agencies to where they were found. In one instance, the finder asserted that a mass of several tons was found in the mountains some sixty miles from any railroad.

About once a year, or oftener, during the thirties, a sample would arrive from the mountainous terrain bordering the Columbia River. The specific locations of these samples always were kept more or less secret, however. I suspected that they may all have come from the same mass because all of them showed the same structure, but all efforts to obtain exact field information failed and we never were able to investigate the source. Others have reported similar experiences of failure in attempts to secure accurate information as to the location source of iron samples from the northwest.

These apparently unanswerable riddles were one thing, but all across the country in the twenties and thirties, leading universities, colleges and museums were exhibiting spurious specimens as meteorites or the reverse—displaying true meteorites under labels of ordinary rocks and minerals.

In 1931 I stopped at a Canadian university to view a mineral collection reputed to be one of the finest on the North American continent. I went up and down the aisles looking over the cases of beautiful minerals that filled the room from one end to the other. When I reached the display of heavier iron minerals I saw a little specimen I was sure must be an an iron meteorite. It was labeled as magnetite from Leeds, Quebec. I hunted up the custodian to ask permission to examine the specimen, but was told there was no way of obtaining access to any of the cases, and that certainly there could be no error in the labeling since the curator was one of the top mineralogists of North America. Finally I found my way to the curator's office and asked an assistant if I might check the specimen in question. He was insulted on behalf of the absent curator, but he reluctantly agreed to open the case for me. With his permission I used an emery wheel in the museum shop to grind just a little corner of the specimen, where it promptly showed bright metal instead of the black magnetite. When we ground down a bit more I polished it by hand and then etched it, bringing out a beautiful Widmanstatten figure.

The little Leeds iron was magnetic; it was black, or rather dark brown;

it was heavy. Magnetite has all of those qualities. And so the little Leeds iron, an immigrant to our planet, was given membership in the great family of terrestrial iron ores.

At eight different times in eight different institutions I found meteorites masquerading under other labels. As many times or more I discovered terrestrial rocks classified as meteorites.

The Rosebud meteorite previously discussed, which was pronounced to be a wind-blasted lava boulder was covered over every square centimeter of its surface with fusion crust such as is found on no other rock. It bore hundreds of characteristic pits or pizoglyphs. It showed perfect orientation of those pits and absolutely no marks of terrestrial erosion. Yet the entire geology staff of a university gave it an erroneous classification. Perhaps those men had been trained as readers and memorizers of text books, presented with solved problems. I heard a geologist deliver a popular lecture within sight of perfect examples of all types of faulting, erosion, lava flows, talus slopes and fans, while using only book illustrations which referred to features hundreds or thousands of miles away.

In 1931, when I was passing through a university city, I telephoned the department of geology to ask if there was a collection of meteorites. I was informed they had one meteorite, which Dr. Oliver C. Farrington had identified for them a few months before after it had lain in the rock collection for fifteen years as a favorite example of glacially scratched boulders. This was the beautiful little Lafayette, Indiana, stone, one of the most perfect and beautiful of oriented specimens. All of its most important features—its orientation, fusion encrustation, crinkly glass thread lines and readily distinguishable forward and rear surfaces—had been described in print, with illustrations, as they related to other meteorites.

In one university museum two polished sections of a stony meteorite were exhibited as limonite, while the third fragment of the same meteorite lay in a box of discards destined for the city dump until I rescued it.

Following a lecture in Fort Worth, Texas, in the middle thirties, I invited questions from the audience of geological society members. After several other queries, a middle-aged geologist spoke up in a tone that reflected both impatience and skepticism:

"What evidence have you or anyone else that any of those specimens which you displayed tonight came from out of space?"

### 3

Many times results followed a long while after the event, and a tour of lectures or exploration would be capped with success years later, or miles away, or through some indirect association.

A lecture I gave in the Sharon Springs, Kansas, school about 1933, yielded only one visible result at the time. It brought me into acquaintance with Mr. R. A. Dollarhide, who then was the telegraph operator at the railroad station in that town. Dollarhide was an avid collector of Indian artifacts and various kinds of rocks.

He sent in a few samples, none of which proved to be meteoritic; and I lost track of him for some time. Then he sent in a chip that he said had been taken from a mass of several hundred pounds near the village of Morland, Kansas, where he was telegrapher at that time.

This was in 1935, a year of heavy expense for us, and I was broke. But Dollarhide's sample was genuine and his story was good. Dean Gillespie agreed to put up money for the trip and purchase of the meteorite in return for half interest.

I made the trip at once. Dollarhide told me where to find the farmer, Sam Hisey, and told me how Sam had broken his lister—a kind of plow—on the meteorite in a field he had farmed for many years. It was "the heaviest darn rock" he had ever seen, Hisey had said, "big as a wasFl tub and in a field where I've never even seen a pebble before."

We went out to the field and what I saw there set my nerves tingling. A mass that weighed later at more than 600 pounds had been pried out of the soil. It had been broken into three pieces, probably at the time of fall, but they plainly could be fitted back together. Morland turned out to be one of the world's eight largest aerolites.

Mr. Hisey had supposed that the stone had arrived since the last year's plowing. However, the meteorite was plainly aged and no doubt had landed long before settlement of the area by white men. It had been embedded near the top of a small hill where erosion by water and wind gradually had lowered the surface several feet, eventually exposing the stone to the plow.

Had Dollarhide not heard the story, investigated it and sent me the small sample, Hisey would have carried out his plan to hitch a team to the troublesome stone and drop it, into a deep ravine that traversed his farm.

As the story of Hisey's find got around, neighbors remembered that a fifty-pound stone of the same kind had been found by an early settler and used in the foundation of a neighboring farm building some fifty years before. Some fragments of this piece, with cement still clinging, were recovered from the building remnants. Years later, another ninety-seven-pound mass was found by pheasant hunters about three miles south of the Hisey farm. This stone lay in a deep ravine under a fence that still held an empty wire loop from which the meteorite evidently had hung and been buried as a "dead man" to hold the fence down. Soil erosion apparently had deepened severely what had been a mere ditch when the fence was erected. Analyses of the three stones proved they belonged to the same fall.

I became more convinced than ever that there must be hundreds of other meteorites that went unfound because the margin of chance was not in their favor.

Our methods of field search were built on logic in a situation where the mathematical odds against us necessarily were great. We had studied our map of the Great Plains thoroughly. In the southwestern corner of Kansas there was a block of six counties from which not a single meteorite ever had been reported. This was strange in an area where soil conditions and density of population were favorable to the finding of specimens. Alex Richards was instructed to concentrate on this area. He worked persistently, lecturing in high schools, speaking before clubs and reaching by personal contact as many persons as he could. But our small fund for the assignment soon was exhausted, with nothing to show for it but the recorded fact that hundreds of school pupils and other hundreds of parents had been offered acquaintance with meteorites.

Again and again, as we were able, we invaded more and more of this area of some 6,000 square miles. Repeated negative results failed to dent my certainty that meteorites were distributed indiscriminately and that failure to find them reflected only the incompleteness of search.

In March, 1935, Bob and I were returning from a trip into New Mexico and chose a route through southwestern Kansas in the midst of dust bowl storms that were blowing acres of topsoil from the farms. At the end of four days of discouraging battle with dust-laden winds and sandblown roads, we drove wearily into the county-seat town of Hugoton, Kansas. We stayed the night with former students of mine, the Hubbards. These hospitable people were tireless in their efforts to make us comfortable in spite of blowing dirt, but when we awoke in what had been a freshly cleaned room the night before, the once immaculate bed linen was the color of creamed coffee, with two incongruous white spots where our heads had rested on the pillows, and our feet plainly tracked the floor.

Hubbard urged us to arrange for a lecture in the high school, but we were anxious to be on our way. Then he mentioned that the principal was another student of mine and I changed my plans. I was greeted warmly at the school and invited to address a special assembly. Since there was not time for the janitor to remove the deposit of blown-in dust from the auditorium seats, the lecture was given in the library, where the 300 pupils sat on chairs or table tops or stood, all of them examining with interest the specimens I sent around for inspection.

At the close of my talk a senior boy, John D. Lynch, Jr., came forward and told me that one of the specimens resembled a stone his father and he had plowed out with the lister some years before. The stone had been thrown under the fence and, so far as he knew, was still there.

Bob and I, with Hubbard and the boy, drove out to the farm. The stone was found, just a corner still protruding from a sand drift rapidly forming under the fence. It was plain the sixteen-pound object was but a fragment of a much larger mass, probably severed by the plow. We followed the corn rows a half mile into the field to the spot where John Lynch recalled the meteorite that had been plowed out. There we soon found fragments of meteorite that had been scattered during the intervening years of cultivation over an area of about an acre. I began scratching with a shovel where the concentration was heaviest. Hubbard wielded a second shovel and soon we could hear fragments grating against the implements at every stroke. All were sifted out carefully and set aside, and we proceeded cautiously with our digging, on the lookout not to disturb any piece that seemed to be anchored, for fear of destroying the parent mass which must be in an advanced stage of decay.

Soon Hubbard struck stone that seemed to be anchored, and a moment later I did also. The two were twenty inches apart. It was like drawing straws—who would get the big one? We laid our shovels aside and scratched away with bare hands, excited as treasure hunters. In answer to repeated queries I predicted that we might find a stone weighing so much as 200 pounds, though I doubted it, since our two protuberances were not deeply buried.

Five of us dug—Bob and I, Hubbard, the Lynch boy and a friend of his. We worked patiently in two rival groups, one at each knob, until we excitedly found we were all working on the same large mass! By noon we had unearthed the second largest stony meteorite ever discovered, a weathered brown aerolite of 749 pounds, with twenty-one pounds more of separated fragments. During several seasons of cultivation, more fragments were gathered, bringing the total to near 900 pounds.

We uncovered the stone and photographed it where it rested. Then it was wrapped in burlap and plaster over two thicknesses of damp newspaper. Two six-foot lengths of gas pipe were wrapped into the plaster jacket to serve as handles. When the plaster had set, six men lifted the mass into a trailer for the move to Denver. Then the wrappings were removed and the more broken portions were taken apart piece by piece, cleaned, and set together again with plaster and gum arabic. The extreme upper portion had been so crumbled in the soil that it could not be reassembled. A plaster base was built onto this disintegrated end to serve as a permanent support, reversing the position of the stone as found.

Recovery of the great Hugoton stone was dependent upon a series of chances—our selection of the return route from New Mexico and our visit to the Hubbards; the last-minute decision to call at the school; the hastily arranged lecture and the presence of John Lynch, who graduated from the school only weeks later; a thoughtful boy's memory and curiosity; finding of the nearly buried fragment before the wind-drifted sand completely buried it. This remarkable find came at the end of four months of otherwise fruitless field work.

All in all, the thirties—such bad years in so many ways—were good years for adding to man's knowledge and inventory of meteorites. Perhaps it was because in those dreary, worrisome days people were glad for a new interest, especially if it offered a slight chance of obtaining money. More likely it was because these were the first years anyone had given all of his time searching for and studying these visitors from outer space.

In 1936 I called in Alex Richards.

"I want you to go down to Gladstone, New Mexico, set up your tent and stay three weeks," I told him. "Keep your meteorite samples on display in that country store and try to contact every farmer. There should be a meteorite somewhere thereabouts because none has been found nearer than about twelve miles, and quite a lot of land is under cultivation."

At the end of two weeks Alex wrote that he had found no leads, he had seen every farmer and rancher in the vicinity, he himself had walked fields and pastures until he was so sore and stiff he couldn't sleep. Should he stay on another week or go to the next location?

"Stay on," I answered.

Three days after he wrote that letter, a rancher who had been passing by his display and ignoring it regularly finally stopped to look.

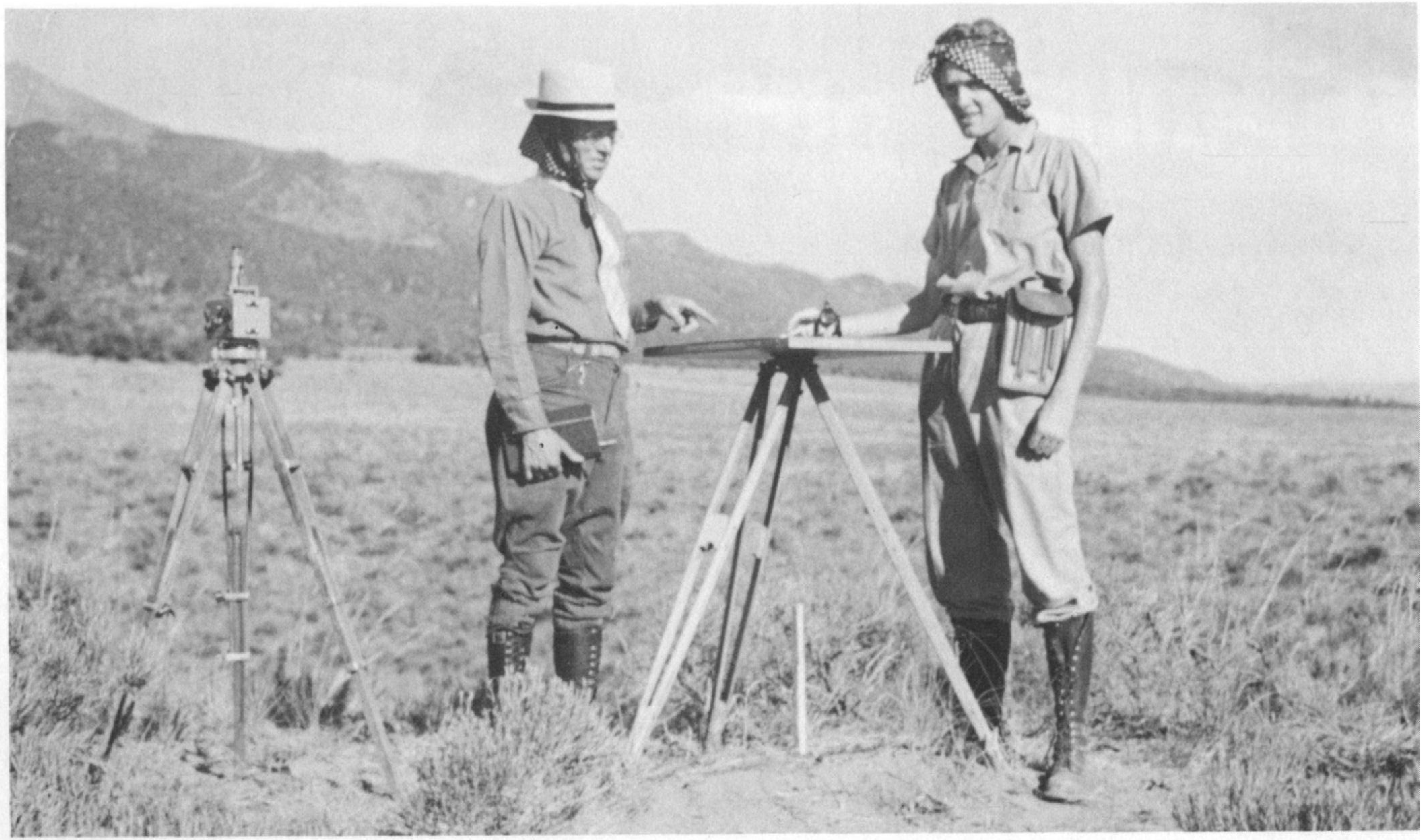
"Is that the kind of stuff you offer to buy?" he asked. "Hell! I've got one as big as a coal bucket."

Alex promptly bought his meteorite, a 128-pound stone that had been lying up against the barn ever since it had been plowed up four years earlier. And within a week Alex purchased four others, representing three different falls.

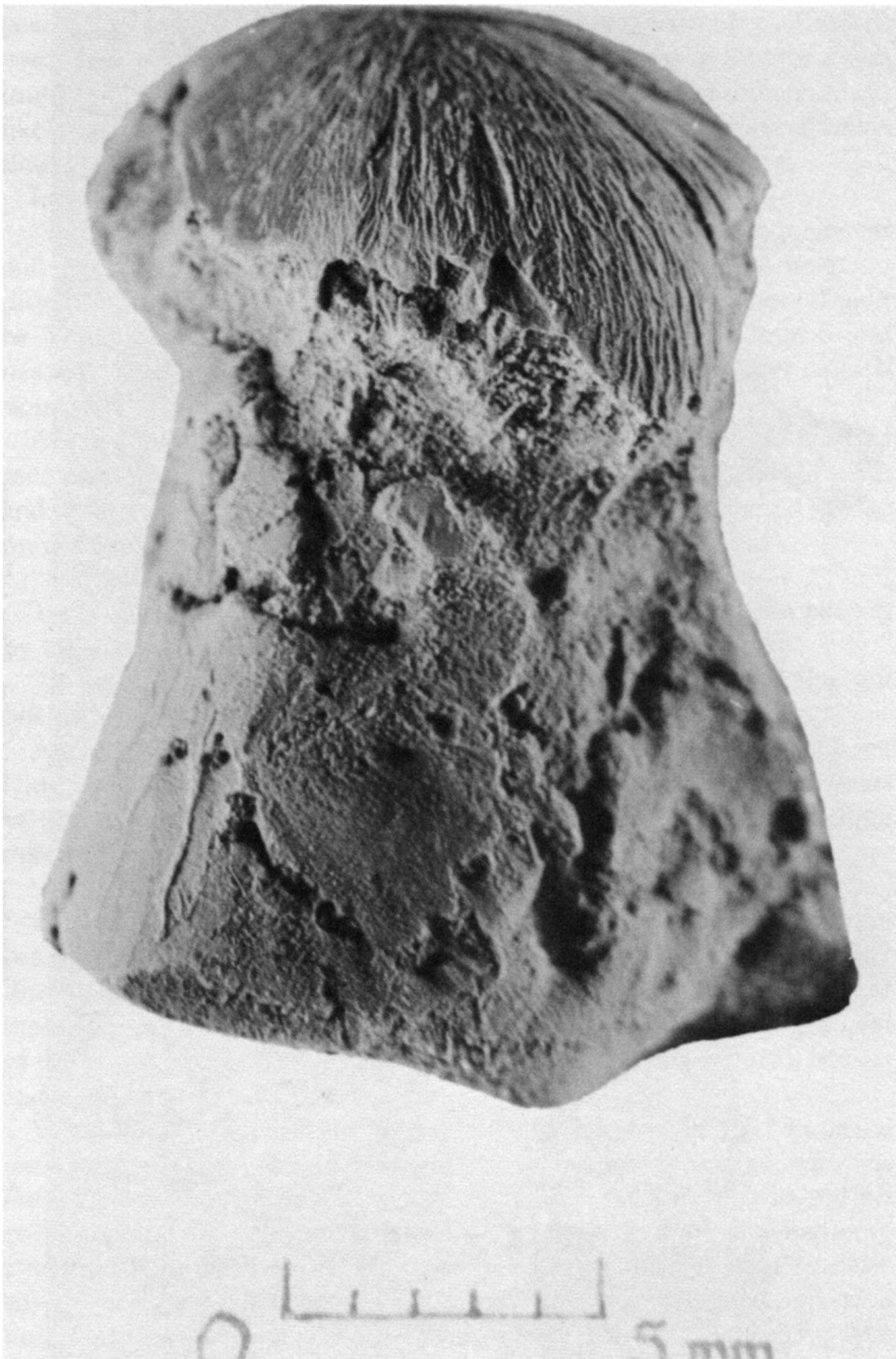
During 1937 thirty-one previously unknown meteorite falls were recovered by our little organization—more than had been recorded in any three-year period throughout the entire history of the world. None of these were seen to fall, so there was no exciting event to stir any segment of the population into observational activity beyond our lectures, leaflets and newspaper stories.

When I first went through the town of Miami, Texas, in 1937 I noticed the courthouse was surrounded by fossils, and went inside to ask who was the collector. I talked to the hobbyist, Judge J. A. Meade, admired his collection and asked if during his field work he ever had happened onto a meteorite. Judge Meade said he had never seen one and wasn't sure he would recognize one if he did. I showed him some specimens and left a little sample of a stony meteorite with him.

Field work took me through Miami several times in a brief period, and each time I stopped to visit with the judge. At last he reported that he had located a meteorite, but he said he couldn't talk the farmer into bringing it into town. The judge said it was just like the sample I had given him, but "as big as a half bushel measure."



*Operations at Crestone Crater. Plane table survey.*




*A blunt-nosed, oriented, nickel-iron meteorite which fell at Estherville, Iowa in 1879.*

Judge Meade told me how to reach the farm of Mr. Thornhill, fourteen miles out from town. When I reached there, the farmer was busy, training a young stallion. There was no sign of a meteorite about the yard. When I told him of my conversation with the judge, Thornhill insisted he didn't remember any such thing. Finally I brought a specimen from the car.

"If you can remember where it is, and if the meteorite is genuine, I'll pay you fifty dollars, sight unseen."

Immediately the farmer yelled for his hired hand.

"Flaky, show these men where Arkansas built the fence for us."

Thornhill explained that the fence builder had taken a pile of white caliche rocks—desert limestone—for dead men, and had carried the "black rock" along for the same purpose.

There were about fifty dead men along the fence line, all of them white but one, and nearly all of them buried at intervals along the two-mile fence wherever it crossed a ditch or a dry wash, as weights to hold the wire down to keep in the cattle. Bob was with me. We both took shovels and started digging down to the dead men. The twenty-sixth was a 127-pound meteorite. We stowed it in the car trunk, gave a check to the farmer and he responded with a broad smile.

"You like fried chicken? Pick out a couple from the pen."

He dressed them and packed them in ice, and directed us to stop at the next restaurant. They fried us a fine fresh chicken dinner.

One hot, windy summer day I sat down at a lunch counter in Sterling, Colorado, and ordered a hamburger sandwich and coffee. I laid a small stony meteorite beside my water glass. Shortly a cattle truck stopped in front and the driver entered and sat down beside me. He wiped the sweat and grime from his face, rubbed the sand from his eyes, wiped his eyeglasses with a napkin, replaced them and reached over and picked up the little meteorite. He examined it briefly and put it down.

"Do you know what it is?" I asked him.

"Well, it looks like a rock."

"Yes, it is a rock, but a very special one. It fell from the sky."

"Oh? you mean it's one of those meters?"

He picked up the meteorite again, hefted it and turned it over. "You're not kidding?"

I assured him I was not.

The driver took a swig of coffee, wiped his mustache and examined the meteorite again.

"You know, my brother-in-law over in Nebraska may have one of those things in his yard. It's a big thing. He bumped into it when he was plowing several years ago in the field where there were no other rocks. He brought it up to the house and it's been lying in the yard ever since."

I asked him how far we were from his brother-in-law's place. The distance, 110 miles, seemed too far to risk a wild goose chase so I handed him a leaflet on how to recognize meteorites and asked him to send another to his brother-in-law. A few weeks later I received a sample of a somewhat old and weathered meteorite that represented a rather rare type. When I went to Nebraska to see it I found the farmer had about 450 pounds of meteorite in the yard and we were able to gather another 150 pounds from the hilltop where he had plowed it up and from a fence row where he had thrown a forty-five pound fragment. This was the Potter, Nebraska, find.

We recovered a total of sixty-five meteorites during 1937-38. Each has something of a story. But to me the most exciting aspect of our mounting success was the fact that my contention that meteorites were an important feature of the earth, both geologically and astronomically, was being proved.

4

Among the most interesting of witnessed meteorite falls is the one that interrupted a burial service being conducted near the little town of Johnstown, Colorado, on July 6, 1924.

The explosions and puffs of gray "smoke" that accompanied the shower of stones were heard and seen by no fewer than 200 persons, mourners in the church yard or workmen in the fields. A fifteen-pound specimen was dug out of the roadside just thirty feet from the church door, where it had fallen with an audible thud and buried itself twenty inches into the ground. A fifty-pound stone was dug immediately from wet ground in which a farmer had seen it bury itself to a depth of five feet. A seven-pound stone and two weighing three and a half pounds each were picked up in fields where they had been seen to strike. Numbers of pea-size to walnut-size stones were gathered between the cemetery, two miles west of Johnstown, and Mead, ten miles south.

Fifteen years after this fall, in 1939, I was invited to address a group of employes of a Denver dry goods firm who wished a speaker on some subject considerably removed from matters of merchandising. After I spoke to the group of about thirty persons, the chairman, Sam Dreith, came over to me.

"I've got a meteorite that I saw fall."

I asked when, where, and he told me it had been about fifteen years before, near Johnstown. He was out raking hay with a team and dump rake when the noise of the meteor frightened his horses. He saw a stone drop not far away in the field, a black stone leaving a little vapor trail, but he didn't break his raking pattern. It was on the next day that he reached that point in the field and his rake kicked up the stone. He carried it home, put it in the bottom of his trunk, and had never taken it out since. When he went home the next week end, he pulled the meteorite from the trunk and brought it to me in Denver. It was a beautifully oriented, fresh looking stone weighing five pounds, perfectly preserved after its long years in storage.

Our field work of 1939 was crowned by recovery of the largest meteorite that Addie and I ever retrieved personally, the one-and-one-third-ton iron meteorite of Goose Lake, California. Discovery of this great meteorite can be credited to a pair of deer hunters. Recovery of the ponderous iron from its lava mesa in uninhabited wilds can be credited to the ingenuity and years of logging experience of two old-time woodsmen, Olin E. Ake and I. C. Everley.

Deer hunting had not been good in the fall of 1938 for Joseph Secco and Clarence Schmidt. Deer were plentiful in the rugged Devil's Garden atop the Modoc lava beds of the extreme northeastern corner of California, but luck had failed the two hunters until they had just one day remaining to get their bucks. In mid-afternoon of the last day, Clarence sat down on a log at the edge of a rocky flat. Joe had started across the clearing to hunt the neighboring forest. Suddenly Clarence heard a strange sound from across the lava field: melodic "pings" and "bongs" as of iron. He followed after his partner. A few hundred feet away he found Joe sitting astride a great irregular brown mass of iron, pounding away at it with a chunk of basalt. The resulting sound seemed to Clarence like a cross between a mission bell and a blacksmith's anvil. Though he never in his life had seen a meteorite, he had read about them, and he told Joe he was sure this must be one.

The boys wanted to take a sample, but with no amount of pounding were they able to detach a fragment. Finally they went back to camp for a meat saw. By the time they cut off a tiny corner of the steely mass their saw was ruined.

During that winter we received a letter from Oakland, California, concerning a large "possible meteorite in northern California" and we added this one to the list of prospects to be investigated as soon as we could arrange for a trip to that state. We received a second report of a suspected large meteorite from Dr. Frederick C. Leonard of the University of California at Los Angeles, who was a great enthusiast about meteorites. He talked of almost nothing else. As an astronomer he looked at the study of meteorites as astronomical; I insisted that it was as much a geological as an astronomical subject.

The following April when we were in Los Angeles, Dr. Leonard showed us a small sample of this "questionable" meteorite. Leonard said he was puzzled; that he had thought the piece to be meteoritic but had been given a rather indefinite report by the geology department following examination of the specimen. He wanted my opinion—which was, at once and with no uncertainty, that the material was genuinely meteoritic. Immediately then, Leonard wanted to know what was the proper procedure to undertake to recover the mass. First, I told him, we must learn whether the specimen lay on public or private land. From the general locality of the reported site, it appeared the land might be government-owned, in which case a report would have to be made to the United States National Museum. Leonard asked me to proceed with a recovery effort, but stressed that he wanted very much to participate.

Addie and I drove to Oakland, where I talked with Dr. Earl G. Linsley, director of Chabot Observatory, who had written the first letter we had received about the possible meteorite and who referred us to Clarence Schmidt. We sought him out and arranged for him to go with us to the northeastern corner of the state and lead us to the meteorite. We also secured from the Forest Service a promise that a surveyor would undertake immediately to determine the ownership of the land involved.

Because Schmidt had not returned to the spot, he realized it might be difficult to relocate the meteorite. He knew it lay in a clearing on top of the lava mesa out of Alturas, but this was vast and rugged territory.

Addie, Schmidt and I started out, driving first to Alturas and then going some thirty miles farther tortuously and ruggedly over dirt road to the foot of the lava mesa that rises from the western shore of Goose Lake to earn its name of Devil's Garden. A logging road led by a round-about course to the "Garden," fifteen miles away, but melting snows had rendered it impassable for ordinary passenger vehicles. Schmidt thought he could lead us on foot by a much shorter course. We spent a half day tramping through dense forest, up canyons and over ridges, and finally reached the top of the mesa only to find we were in the wrong spot. Disappointed and tired, we returned to camp.

The next morning we obtained horses and rode the longer way round. This time Schmidt led us to the magnificent iron, lying just as he had seen it before and just as it had lain no doubt for centuries. We rode back down to civilization, telephoned to Dr. Leonard and invited him to come join in the fun, and made plans to bring the meteorite down from the mountain.

Everley and Ake, with two of their neighbors, rigged up a four-ton log wagon, drawn by four heavy draft horses, with a block and tackle, and loaded it down with other tools, bedding and provisions and cameras. Dr. Linsley and an assistant had arrived with a panel truck. Dr. Leonard, accompanied by Dr. Robert Webb, professor of geology at U.C.L.A., was en route. Leaving word for the two Los Angeles professors that the first half of the climb could be made by auto, we set out on foot, following the wagon, hoping they would catch up with us. When we were about half way up the mesa slope we could hear Dr. Webb calling and I ran back down the trail to meet him and Dr. Leonard, who had driven as far as the road permitted. We all walked on, soon overtaking the wagon. We reached the mesa top and then proceeded across the two miles or so of boulder-strewn, muddy mesa, dodging ponds and fording small streams of spring run-off, until we approached the meteorite where it lay on reasonably dry, boulder-paved terrain.

Frederick Leonard had shed most of his academic dignity by this time. When we came within sight of the big iron the pudgy little professor ran on ahead, placed his hands lovingly on the great meteorite, bent and kissed it. Then he lifted his hands skyward and turned to face us.

"This is the greatest day in meteoric astronomy!"

Now we all joined in to fondle the prize, an almost unbelievable chunk of metal that seemed to link us, there in that wild corner of the earth, with worlds beyond.

We examined and photographed the mass where it lay and then made camp.

The next morning the men worked for hours with block and tackle, trying to load that mass of iron on the wagon. They had constructed a tripod of timbers cut from the nearby forest, and they tried to slide and haul and push the meteorite up this crude ramp to the wagon. There were several breakdowns and repairs but finally, after persistent efforts and with infinite patience, the loading was completed.

Some miles of almost hub-deep mud, boulders, treacherous ponds and streams lay before us. Scouts went ahead to pick out a course and in some cases to build a makeshift road, clearing away boulders, filling in low spots with rocks and brush, and cutting down small trees.

It required a day and a half to work our way back down the mountain to the road. There the meteorite was transferred to a truck and taken to San Francisco, where it was displayed at Treasure Island until it was removed eventually to the Smithsonian Institution in Washington. The finding-place was national forest land, and so this great meteorite belongs to the nation.

Who owns a meteorite?

In the popular mind, finder is keeper.

In 1890, Professor Horace Winchell of the University of Minnesota paid a man named Peter Hoagland $105 for a sixty-six-pound meteorite that Hoagland had seen fall as part of a shower in Winnebago county, Iowa. Hoagland had received permission to search for the stone—but from the tenant of the farm rather than the landowner. When the latter determined to assert his rights of ownership, the state supreme court ruled the meteorite was "part of the soil" and so belonged to the owner of the land.

This principle was upheld in the Oregon "iron rock" case a dozen years later. Ivan Hughes had discovered a fifteen-ton iron boulder on land belonging to the Oregon Iron and Steel Company. Hughes told himself, "finders keepers" and decided to appropriate the hugh block of metal for his own. This was no small task for a woodsman in remote forest in 1902, but he believed once the mass was on his premises his ownership would be secure, and so he addressed the removal task with singular ingenuity. He fashioned a capstan with chain anchor and a braided wire rope to wind on it. Then he constructed a log chassis to which he attached sections of logs for wheels. Using improvised blocks and levers, he skillfully engineered the giant meteorite onto his crude carriage and, with windlass and horse, moved it inch by inch and foot by foot three fourths of a mile to his own land.

The ensuing excitement over Hughes' iron rock alerted the steel firm, and suit was filed against Hughes. Again the matter reached a state supreme court, and again it was held that the meteorite constituted "part of the soil." Hughes saw no part of the $20,500 for which the Willamette meteorite was sold, although had it not been for him the meteorite might have remained unfound, and would not be seen by thousands of people annually in the American Museum of Natural History.

During our years of collecting we purchased several thousand specimens without a single complaint ever being filed in court. Where the find had been made by other than the landowner we always recommended a division of the sale price between the finder and the property owner. Usually the owner insisted on the finder receiving the proceeds, although in a few cases the money was split. Some sort of division of ownership between finder and landowner would seem to be an equitable arrangement.

A more sensitive problem than the matter of ownership can arise if one collector "encroaches" on an area of fall to which another makes prior claim on the basis of a program of search already undertaken. When a man or an institution through its representatives in the field discovers the remains of a dinosaur or some other important fossil it is regularly accepted that such discovery establishes a prior right to work in the area until the entire skeleton or skeletons have been safely recovered, assuming, of course, that in any such case proper arrangements have been made with the landowner. A meteorite fall can be studied properly only if all of the recovered material can be examined critically and compared.

The going price to owners of meteorites had been established pretty well before my time at a dollar a pound. We made this our basic figure. Deviations up and down from this figure were based upon the type of specimen, size, state of preservation, special features as to form and surface markings, internal structure and composition, as well as any facts known of the fall. For my predecessors in the collecting field, who collected only casually, the price paid to the finder usually constituted the entire cost to the buyer. For me, however, it often was the minor part of my costs. Sometimes Alex or I or another of our "staff" would spend weeks in the field. Much time too was spent in the office and laboratory, answering the letters and testing the samples that came in response to our program of lectures—many of which were free—leaflets, radio and press appeals. All of these activities were costly in both time and money. By the time a meteorite had been acquired, classified and undergone some study it had become an expensive item. In our most successful year the average cost of acquiring a specimen was about $14 a pound in addition to the price paid to the farmer who owned the land where it was found. At the end of the thirties, in terms of dollars of the thirties, I figured that the average cost of discovering a new meteorite amounted to about $300 in addition to the purchase price. For one who was working on as frayed a shoestring as I was, the rare occasions over the years in which our prior field work was usurped and we lost out in acquisition of the specimens recovered subsequently seemed like major catastrophes.

Selling specimens had drawbacks, too. Word came to me that a man whom I shall call Mr. Von Hess desired to purchase a meteorite which he would then present to an institution. This was sometime in the thirties during unusually tough times, and I could not afford to pass up an opportunity to cash in on a specimen. Because I made it a point to know who had collections of meteorites, I knew that Von Hess had none, but that at one time he had owned a seventy-eight-pound iron which had a rather interesting history. It had been found in 1881, by a sheep herder, Ignacio Martin, who had traded it to Thomas Tobens for a small pony. Tom, believing it to be solid silver and fearing it might be stolen before he could market it, buried it in a manure pile in his barn, and there it lay for several years. Mr. Von Hess heard about it, determined that it was meteoritic, and purchased it for a scientific society.

Since I was told that he wanted "something nice" and that he was well-to-do, I looked forward to a pretty good sale. I selected a very fine specimen, beautiful more than scientifically valuable, to present for his inspection. This was an end piece from the Xiquipilco fall, with a polished face the size of a slice of bread that displayed exquisite Widmanstatten figures. The nicely sculptured natural surfaces were beautifully black. The iron weighed about six pounds and today would be worth $250 and $300.

I was cordially received by Von Hess. He leaned back in his swivel chair and admired the meteorite. He inspected the specimen carefully with a magnifying glass, inquiring as to the technics of polishing and etching. As our conversation proceeded, Von Hess reached into his pocket, took out a pen-knife, opened it and began very casually to scratch an area in the center of the polished and etched surface. I almost cried out. He remarked that the narrow bands were harder than the wide bands in the pattern. Yes, I replied, I knew this, and I might have added that I could have told him as much without his damaging investigation. But I was still consoling myself, or trying to, with the thought that the specimen soon would be his and the arduous re-finishing job would be at his expense, not mine.

No such luck. He greatly appreciated the opportunity to examine the specimen but he didn't believe he was quite ready to make a purchase. All the fortitude I could muster was required to bid him a pleasant "good-day" and betake myself home, contemplating my loss of time already spent and another two days for the regrinding, polishing, etching and administering of anti-rust treatment to the disfigured specimen. Subsequently I was less timid about cautioning prospective customers not to touch the finished face of a specimen.

*Upinion and force belong to different elements. To think that you are able by social disapproval or other coercive means to crush a man's opinion, is as one who fires off a blunderbuss to put out a star.*
*John Morley*

# 8. PROSPECTS AND PROSPECTORS

During the winter of 1940 Addie and I took our house-trailer into the Southwest for some lectures and some follow-up field work.

We parked for a night in the town of Wickenburg, Arizona, and Addie settled down with some reading material and her knitting.

"No telling when we shall be here again," I remarked. "I think I will scout around, see if I can locate some prospectors. We might find a new meteorite."

There was no lead in our files suggesting a meteorite at Wickenburg, but this was in our favor. Since no meteorite ever had been reported from this part of Arizona, there might be one to be discovered. I wandered about the town hang-outs—the drugstore, a bar, a restaurant—asking about prospectors. Twice I was told of a Mr. Kellis, who no longer was prospecting but who for forty years had explored the surrounding hills. I asked directions to his house. After climbing a dozen blocks of dark streets I reached the white house on the hill where he lived in retirement. A large pile of rocks marked the front yard. It was about nine o'clock in the evening, but my knock brought Mr. Kellis to the door, courteous, white-bearded.

When I identified myself and my misison he was quick to tell me I was looking in the wrong area, that I should visit the meteorite crater near Winslow to find what I was seeking.

No, I told him, presently I was more interested in stony meteorites, not Canyon Diablo. I showed him a small specimen from my bag.

"You call that a meteorite? You must be mistaken. Meteorites are made of nickel and iron."

A good deal of persuasion was required to convince him the stone I showed him was a meteorite.

Finally, he shrugged. "Well, you *should* know your business, and if this is a meteorite, I may have one out here in my rock pile."

He brought a flashlight and we went out to his pyramid of rocks. There must have been two tons of stones, and among them, plain in the light, was a twenty-pound meteorite that had lain there for thirty years. Mr. Kellis recalled where he had found it, but he never found another there, nor did we. His was the first stony meteorite to be recorded in the state of Arizona, except from the widely known shower of 1912 at Holbrook, in more than thirty years.

Our luck went up and down. For every exhilarating experience of discovery there were disappointments. There would be months on end during which we worked just as hard, borrowing and spending, without receiving even a sliver of meteorite in compensation. After many years of chasing fireballs I finally accepted recovery of one meteorite from a half dozen surveys as a good average.

I remember struggling for hours in the sand hills of western Nebraska, checking out just one among many reports in an effort to map the course of a fireball. The car sank belly deep in blown sand on a lonely road, many miles from any source of supplies and far from hope of help. Night was approaching and I was beginning to expect to sleep with sand for a blanket. Finally, I foraged weeds at some distance from the car to lay against the wheels and then, by jacking the wheels one by one and by various other contrivances produced enough traction to get under way just as dark closed in. No meteorite ever was recovered from that particular fall, nor from a majority of all those that were mapped over the years.

The leads that sounded best might bring the deepest disappointments. Some of these abortive reports sounded so infallible that it seemed they could not possibly fail to prove good. Every once in a while a tale would prove genuine and traceable and so pay off for some of the false leads. Some of those old stories still haunt me—some of them sound so good, in spite of investigations that produced nothing, that it is hard not to believe they have a core of substance.

On our first visit to Wickenburg, then just a village, in 1926, we met an old prospector with an interesting tale. When I asked him about meteorites he knew what I was talking about.

"I've got three thousand pounds of 'em. Gathered them myself around the crater."

Could I see them?

"No. They're buried."

Would he sell them?

"Yes, if you'll give enough. Want $3,000."

Would he sell part of them?

"No. Won't show anyone where they're buried until I can make a deal for all of them at a dollar a pound."

He was adamant. "If I don't sell them, the secret will die with me."

He said only that the cache was "not too far" from the crater. I never found the old man on later visits to Wickenburg.

Was his story true? The tale fitted the nature of a man old in the ways of prospecting, and experienced in the disappointments and waits and secrets of that manner of life. I'm sure he is no longer alive and am also sure he never disposed of his meteorites. I haven't the slightest idea as to where they were buried.

There were so many tantalizing reports, and one of the most intriguing and convincing was a tale told me by a man in Prescott, Arizona. I had gone into a bar on one of my customary tours of community hang-outs seeking likely individuals with likely stories. I laid a nickel-iron meteorite on the bar beside a man who was drinking a bottle of beer. He looked it over carefully.

"Are those worth anything?"

I told him they were. He stood, looking past me for a moment, as if gathering details out of his memory. Then he pointed to the cigaret vending machine.

"I found one as big as that machine one time, but it's been fifteen years ago." He stroked the little specimen before him on the counter. "It was iron just like that, and had dents in it just like that, and when I hit it with my hammer it sounded just like an anvil. I know it was the very same thing."

He had been a surveyor at the time and was running a line for the government. He told me what line it was. They came to a ravine they couldn't cross and he had gone south about a quarter mile to where it could be negotiated—and there in the ditch was this great hunk of iron.

Neither he nor I had the time nor money to make a ten-day trip to the spot at the time, and I never was able to contact him again. Somehow I lost the notes I scribbeld down, including the man's name. I had fully intended to follow up this lead, having him guide me to the spot. The territory in which he was working is seldom visited by anyone except deer hunters, and it may be a hundred years before another man sees that great iron—if it really exists.

Of all the hundreds of reports I investigated in my years of meteorite hunting, more than a hundred yielded meteorites, and the other hundreds all were duds. Few of the productive tales were more convincing than this man's reports. It is my belief he had found Arizona's finest meteorite specimen. Whether it could be found again is a question.

The "Danforth puzzle" was another of the teasing, unproductive reports that sounded almost too good to be true, but, on the other hand, too good to be decided definitely not to be true.

An enormous fireball was seen over the great Maine wilderness. The next day two men out deer hunting were trudging through a cover of snow over a swampy, timbered area when they came upon a strange scene. The trees on all sides of them were spattered with mud, and right in front of them was a big round hole in the forest floor revealing an underground lake. This hole was nearly round, about nine feet across, and its edges were clean-cut, almost as if they had been cut with a saw. In this swamp the forest floor was simply a tangle of roots in a foot-thick blanket of sphagnum moss that covered a former lake which still persisted under the forest cover. Such conditions were common in that part of Maine, but the hole! Such a hole was something new to those hunters, and it proved no less a puzzle to all who heard their description of it.

So ran the story that was sent to me by George Sprague, who had read one of the magazine stories about my meteorite hunting and who had a hunch that here might be the answer to that strange tale that had reached his ears about the hole in the Maine woods.

His letter intrigued me as much as the tale had interested him. I wrote back for more details. He explained that he and his brothers had visited the spot and found things just about as described by the hunters. They had probed into the pool and had reached a muddy bottom only seven feet below the surface. No scattered roots were found—only mud. This had not been an explosion of gas from below; it must have been caused by an object speeding from above. The only possible answer they could muster was that the hole had been created by a large meteorite. If I would come, Sprague wrote, he would guide me to the spot.

Naturally I would come. Where I would obtain money for the undertaking was one of the unknowns in the problem; but the answer was yes, I would come. Art Thompson came forward this time, offering to take the gamble and eager to go with me to Maine for this adventure. We were met at the town of Lincoln and were driven in a somewhat aging Ford to within a three-hour walk of our destination.

As we approached the spot, shrubs and small trees bowed to our passing, and we found that by standing in one spot and alternately squatting and straightening we could soon have the trees on all sides curtseying gracefully. We were walking over the once open small lake that gradually had succumbed to the encroachment of mosses and ferns and finally had come to support a young forest.

In the midst of this strange floating forest we faced a clean-cut opening to the lake below, cut right through the forest floor. Although it seemed so clean-cut, close examination of the exposed root-ends showed that no cutting instrument had been used. All the roots had been broken as if by a violent blow.

There was no evidence of any lumbering, wood-cutting or other human activity in the vicinity or, according to our guide, for miles around.

A few years had elapsed since the hunters first had found this hole; consequently, all mud had been washed from the tree trunks, if they had once been spattered as reported; but there still was evidence of violence dating back to the time of the hunters' report. The top of a sapling near the hole had been cut off, and the annual rings in the healing growth corresponded to the time of the first report. Also, bark had been knocked from the trunk of another tree a few feet from the hole, yet we found no scattered roots such as one would expect to find if any had been thrown out by the force that cut the hole.

We prodded the pool and found muddy bottom overlying gravel at a depth of seven feet. A drill bit brought up nothing but granitic gravel when it refused to go deeper. Our mine detector failed to register anything, even though Art, an adept operator, explored all within a radius of some fifty yards. A search for fragments of any odd-looking stony matter was also in vain. We returned baffled and by no means satisfied.

Thompson and I made this initial trip in the late thirties. I was able to secure funds to employ a magnetometer operator to go with me on a second trip to the spot. Our results were no better than the first time. The same was true of other efforts over a decade.

Two possible explanations came to mind:

1) A stony meteorite of an extremely fragile and friable variety may have perforated the forest floor and skidded some distance on the muddy lake bottom. Such a mass would not respond to the instruments that we used.

2) A very unsupported, but possible, hypothesis is that an ice meteorite (a variety not yet proven to exist) cut the hole and left no other trace of itself.

It was suggested that pehraps a bomb or a box of explosives had been dropped from a military plane from a military installation not too far away, but this idea seems a bit far-fetched; besides, the evidence appears to point to a cutting agent too large to fit such a solution. Also, our careful search for indications of anything associated with explosive devices proved fruitless.

## 2

Accompanying many and probably all falls of ponderable stones and irons there is a far greater weight of finely divided material (of dust, sand and gravel sizes) that is showered over several square miles. What we collect as meteorites represents merely a small remnant of that which entered the atmosphere. Under stress of its impact on the atmosphere a meteorite disintegrates and only the fragments that accidentally escape the general disintegration of the mass reach the ground as stones or irons.

Efforts have been made intermittently for more than a century to collect meteoritic or cosmic dust. Two sources—sea-bottom oozes and the arctic snows—were searched for matter of such origin. I tried several methods.

Finally, in September, 1938, on the assumption that considerable portions of meteoritic matter would be magnetic, I utilized an alnico magnet wrapped in rubber (to prevent nickel contamination from the magnet) to collect material at the exits of roof downspouts. These proved to be a fruitful source of a heavy, slate-gray dust which gave a positive nickel reaction. Microsopically, the material was seen to be composed of irregular particles among which were multitudes of minute spherical globules, many of them highly magnetic.

To remove our experiments from city contaminants we traveled to a remote mountain top and anchored a vessel to a mast made fast to the top of a tree at the 11,000-foot summit. This was left in place seven months. We collected and melted ice from the surface of a mountian lake; searched the rough bark of trees by means of a magnetic device, and floated a magnet from a weather observation balloon for six hours in a twenty-mile wind over a snow-clad mountain. For seven days air was sucked over powerful magnets by an electric fan on the top of a high tower. By these means the same kind of material was collected, but in immeasurably small quantities.

The collections from downspouts permitted a crude measurement of the rate at which the material accumulated, as each rain shower or melting snowfall washed off the accumulation since the previous washing so that regular collections after each shower supplied quantitative data. The rate of fall indicated was on the order of several thousand grams per square mile annually, figures in strong contrast to previous estimates of an increment of only ten to one hundred grams annually on a square mile of surface.

If such quantities of meteoritic matter are arriving on earth, why should the soil not be very rich in nickel and why should we not be knee-deep in meteoritic dust? Nickel leaches rapidly out of oxidized meteorites. The surface of the soil is so churned and altered by the ordinary forces of weathering that the most scrutinizing search would be necessary to find even a trace of a rain of spacial matter, even though in the course of a million years it might amount to a layer several inches thick. A layer only the thickness of ordinary paper might accumulate in a period of a thousand years.

The study of several hundred meteorite falls and spectographic studies of meteor trains have shown that the great bulk of this cosmic dust should be nonmagnetic, but no satisfactory identification method has been devised for the nonmagnetic portion of dust.

I was convinced that the comparatively crude methods I was using pointed the way to a study that could be of real value. I suggested such a controlled research project, on a scale of scientific significance, as part of detailed plans that I formulated proposing establishment of an institution devoted to meteoritical studies—the long-time dream which seemed then about to become a reality, but that very shortly was to fade.

Almost since we had first become acquainted through correspondence in 1930, Frederick Leonard had been urging the establishment of a meteoritical organization. My early reaction was that I favored the idea but was opposed to taking any official part. My entire time then was being devoted to meteoritical problems and I feared that participation in administration of a formal society would only interfere, so far as I was concerned, with that which it proposed to promote. When we met for the first time in July of 1932 Leonard pursued the matter, and on September 2, 1932,1 wrote Leonard I was willing to help him set up an organization.

An organizational meeting was announced for August, 1933, at the Field Museum of Natural History in Chicago. A small but eager group attended and established the *Society for Research on Meteorites.* Leonard was made first president of the group and I became secretary-treasurer.

The organization enjoyed a rather healthy growth. At the end of the first four-year term of office I was elevated to the presidency. By the end of my service in that post the membership had grown to something like 160, with several countries represented.

In 1935 I taught a night course on the downtown campus of the University of Denver, the first college course in meteoritics offered by an institution. The enrollment was small, but the response was enthusiastic.

In 1941, in my report as retiring president of the Society for Research on Meteorites, I was able to say that such courses were being offered in at least two American universities, that more than a score of new institutions had been added to the rather meager list of those possessing worthy study collections of meteorites, and that for the first time a textbook on geology had appeared wherein several pages were devoted to the subject of meteorites.

It seemed there was growing awareness of the importance of meteorites and there were growing numbers of individuals interested in devoting time to promoting research and study of meteorites. My hopes grew that there might develop a means by which my own knowledge and interest in the field could be channeled in some way that would involve lesser battles for mere survival. Absorbed as I was in recovery and study of meteorites, I tried ceaselessly to interest individuals and institutions in establishing kinds of investigations and searches and researches that were beyond my personal capacity to undertake.

In 1933, at the organizational meeting of the Society for Research on Meteorites, I set forth "A Suggested Program of Research on Meteorites." An outline of this address, carried in the November, 1933 issue of *Popular Astronomy* includes as Steps 5 and 6 the following:

5. Relation of meteorites to earth-growth, both past and present, will prove a very important and fruitful field:
   (a) As evidenced in traces of huge crater-producing meteorites;
   (b) As evidenced by traces of meteorites in various geological

formations, when we have learned to recognize them;

(c) As evidenced by the possible causal relation between certain major topographical features of the earth and the impact of meteorites of asteroidal dimensions.

6. The possible relation of huge impacts to the glacial periods and the shifting of the poles of the earth.

In a lengthy paper presented before the American Association for the Advancement of Science in Minneapolis, June 25, 1935, I visualized a comprehensive program of recovery and study. I proposed a National Institute of Meteoritical Research, and recommended a country-wide alerting system.

> Photographs are of inestimable value in the work of locating and determining the magnitude of falls. The institution would have to maintain in operation at all times several batteries of cameras, equipped to operate automatically by photo-electric cells, trapping the record of any fireball of large magnitude which falls within its range of vision. These batteries would be operated in connection with various selected institutions spaced approximately 300 to 400 miles apart throughout the country. Each battery would be composed of cameras pointing to the various sections of the sky so that in case of fireballs of the magnitude which deliver meteorites they should be definitely recorded by two or more stations photographically.
>
> In cases where the meteor, or fireball, leaves a persistent train, or cloud, these automatic batteries would be supplemented by operators with ordinary cameras. Photographs of these clouds are notably scarce in our records. Yet a careful check over only a part of the United States during the last several years has demonstrated that it will be possible each year to secure photographs of several persistent clouds left in the wake of falling meteorites. The significance of these clouds must be a very important matter, yet almost nothing is known about them at the present time, either as to the process of formation or the material of which they are composed. Nothing whatever is known concerning the mass of meteoritic material which they represent. . . .
>
> When the approximate location of a meteorite fall has been determined, there should be an immediate visit to the locality by a designated investigator. By telephone, the local newspaper, and personal canvass, he could inform residents what to look for, its scientific importance, and its preservation. . . . This investigator should remain in the vicinity until the collection of all the immediately available material has been completed.

At the close of a lecture I gave in the Adler Planetarium in Chicago early in 1936, Dr. Forrest Ray Moulton came to the platform and introduced himself. I was a great admirer of Moulton, who was one of the giants of American science during the first half of this century. With T. C. Chamberlin he was co-author of the planetesimal hypothesis of the origin of the earth that dominated much of the thinking in the fields of astronomy and geology for several decades after the turn of the century.

He was most complimentary and we chatted for some time in the emptying auditorium and then went on to his home. He expressed great interest in the work I was doing and asked some questions as to how it was being financed. When I described my program of searching for meteorites, selling of part of them and lecturing as a means of both aiding the search and helping to pay for it, he wondered aloud why my home city of Denver had not come forward with some manner of help. This I could not answer, but I had to admit the reason might be because it had not been asked for anything.

Dr. Moulton then suggested that he would like to come out to Denver and approach such organizations as the Chamber of Commerce, the Colorado Museum of Natural History and the University of Denver on my behalf. I was surprised and heartened by this unexpected offer of help from a man who was a member of the National Academy of Science, the American Philosophical Society, the National Research Council and numerous other important scientific organizations; the author of several books; recognized authority on ballistics and celestial mechanics; and one of the leading mathematicians of the nation.

In December of that year Dr. Moulton came to Denver to undertake advance planning for the meeting of the American Association for the Advancement of Science to be held in Denver in June, 1937. During this visit he studied the collection of meteorites at the Colorado Museum of Natural History and addressed a dinner gathering of city officials and community leaders arranged by Dean Gillespie. Dr. Moulton announced to the guests and newsmen that Denver was being considered by the National Academy of Sciences as a possible headquarters for a national institute for study of meteorites. He described Denver as an ideal site for such a center and specifically praised the meteoritical research work being done by me and by the Museum, suggesting also the possibility of a grant to me for some immediate researches as a preliminary step toward large-scale operations from Denver.

Dr. Moulton not only lent his great prestige to my work and focused the hopes I had held so long for a more solid and formal program in meteoritics; he made an immediate and positive contribution to my efforts by using his good offices to secure a grant for additional work at the Haviland crater in Kansas. It was soon apparent that formation of a center by the National Academy, as he envisioned it, was not to come to pass.

In 1938, a committee was organized in Denver, led by Frank Cross and the Chamber of Commerce, for a proposed American Foundation for Meteorite Research, to be supported by sustaining and contributing memberships, with printed praises and good wishes from scientific colleagues around the country, but this also faded. Then, in 1939-40, hope brightened with what looked like a very real opportunity for foundational support, but this too proved to be just a flash in the pan.

While I was in the East on a lecture tour in the fall of 1939, word reached me that the late Spencer Penrose, widely known philanthropist, financier and mining man of Colorado, had designated that his estate of several millions of dollars be used for support of charitable, educational and scientific purposes within the state of Colorado.

Many scientists throughout the country seemed to see this as my great opportunity. Twenty-three letters from eminent geologists and astronomers who shared my desire to see a vigorous and productive program instituted in meteoritics, were gathered for submission to the Penrose *El Pomar* Foundation. Again, Dean Gillespie helped. All the old hopes and plans were dusted off; new ones were added, and the whole bound together, complete with blueprints donated by a noted Denver architect, for a proposed Institute of Meteoritical Research, and transmitted by the Denver Chamber of Commerce to the Foundation.

The first two or three interviews with spokesmen of the *El Pomar* Foundation were most encouraging. Then, armed with my prospectus, I met with the Foundation's board of directors. They heard me favorably, but because of the absence of one of their members postponed definite action until a later meeting to which I was to bring more detailed budget information. The next word from the board was that they had decided against any further consideration of the proposal for a meteoritical institute.

Plans for the Institute had included detailed proposals for field work, for an educational program, research fellowships, cooperation with other interested agencies and individuals throughout the nation and overseas, provision for exhibit of meteorites, publication of scientific papers and a monthly bulletin. The director of the Institute would have received a salary of $5,000 a year. The Nininger Collection was to have been donated to the Institute.

The extensive field program envisioned in 1939 was to provide for study of the relationships of meteoric phenomena with long-term weather forecasting, solar radiation and conditions of the upper atmosphere; study of the chemical composition of meteorites with respect to such problems as rust resistance of metals and formulae for steel alloys; exhaustive study of the non-terrestrial minerals found in meteorites; investigation of the explosive disintegration which marks the luminous flights of meteorites, and detailed study of heat effects registered in the fragments recovered, to throw new light on the problems of air resistance to high velocities and of stratospheric transportation; study of the forms and markings of meteorites as an aid to high-velocity ballistics engineering; possible relationships with cosmic rays; study and measurement of meteoritic dust and any effects it might have on the growth of vegetation and the healthy development of animal life; research into the possible existence of "ethaerial (from ether and aerial) sound" in connection with the flights of great meteors.

The recovery program included extensive plans for the alerting of and cooperative efforts among a network of institutions and agencies so there might be prompt and efficient action on appearance of a fireball, not only to plot the probable locality of fall and alert both trained staff people and the general populace for the recovery of specimens, but to study the light phenomenon and its accompanying dust cloud and sound waves.

Such a comprehensive program was not to be in the 1940's, nor has such an extensive and coordinated plan ever been effected.

3

From the steps of the Denver Museum of Natural History one can enjoy the finest landscape view of any museum in America, looking across to the west where the gigantic peaks of the Rockies rise in a succession of billowy folds of crustal rocks which have lain exposed to the forces of weathering through perhaps a hundred million years. How frequent during that time have been the impacts of meteorites on those mountain peaks?

Perhaps one fall a year has landed within the area under observation. If these falls average as large a number of fragments as have the falls recorded in man's experience, then a tremendous number of meteorites have landed in those mountains. If so, where would they be now? Only five falls have been recovered out of the area, and of these, only one was witnessed.

One must allow that most of the meteorites buried themselves at the time of the fall so deeply that if they were stones they would for the most part disintegrate before the process of erosion would reveal them. Or, if instead of striking soil, which would accommodate their interment, they struck a solid rock, then they must have been shattered so badly that they would escape notice of any passerby and within a few years would weather so as to be rendered undistinguishable from ordinary rocks. Then, too, perhaps less than one per cent of the surface in the region under view is trodden by man in the course of a generation.

No meteorite whose fall occurred more than a few centuries ago would be recognizable now unless it were of the iron variety. On this point there is interesting conjecture: For though man's experience during the past convinces us that about twenty-five stony meteorites fall for every iron, yet Western Colorado has yielded four iron meteorites representing as many falls and only one stony fall, the Johnstown shower of July 6, 1924.

It might well be assumed that mixed up with the Rocky Mountain sand, silt and gravel which has been swept out of their descending canyons during millions of years and added to the soils of the Mississippi Valley are the remains of millions of meteorites about which nothing more definite can ever be known.

If there indeed are meteorites in old formations, what are some of the reasons why such remnants go unrecognized, and in what ways might they be identified and recorded?

Various attempts have been made to explain this assumed "absence of meteorites from all but the most recent formations," one hypothesis, advanced by several writers, being predicated on assigning a comparatively late origin for these small additions to our planet. To account for such a brief and recent accretion, some radical changes in the history of the solar system have been suggested.

It is my belief that in the present state of our knowledge (or lack of it) we are not justified in considering the "absence of meteorites from the older sediments" a problem at all, for the very simple reason that we have no credible evidence that meteorites in a terrestrialized form are *not* present in all of the sediments. The oxidized meteorites I took from the Haviland, Kansas, crater were so altered as to be mistaken for ordinary iron concretions.

If the failure of geologists to find meteorites in old formations is taken as evidence that they are absent, then by the same token we could have known in 1930 that there were no meteorites in or upon the soil of a 25,000-square-mile area of Texas, an area certainly far better known to geologists and to laymen than any pre-Pleistocene deposit of similar area anywhere in the world; yet, beginning in 1933, my own efforts recovered from that Texas area within ten years more than a thousand meteorites, all of which evidently had been on the earth a long time.

A few months in the field observing mining operations and miners; road-building operations and other excavation activities; talking to superintendents, foremen and both skilled and unskilled operators, would firmly convince the observer that even though thousands of meteorites had been moved by such operations the chances of a single one being found are very slim indeed.

No adequate search ever has been made to determine whether meteorites are or are not present in any of the older formations. Indeed, a search sufficient to warrant an answer to the question would be rather difficult to make unless it should turn out that the older formations are considerably richer in meteorites than are the recent alluvia and other top sediments. In the first place, only a very small portion of any of those formations is accessible and, in the second place, the geological profession has never made such a search possible by training its personnel in the art of identifying even fresh meteorites, to say nothing of those that have undergone long weathering.

The cretaceous chalk beds of western Kansas afford a very extensive exposure of an ancient formation, one that is easily accessible, and that has long been a favorite hunting ground for paleontologists. The chalk is of a color which contrasts strongly with that of meteorites as we know them. During the past eighty years these beds have been visited by probably several thousand geologists, including students. I interviewed many of these geologists during my fourteen years of residence in Kansas and subsequently. By their own admission less than two per cent ever thought of looking for meteorites during field trips; an equally small percentage felt that they would have recognized a meteorite had they seen one.

The likelihood of a meteorite being recognized in such a situation is lessened greatly by the fact that no one knows exactly what changes such material would undergo during 60 to 100 million years. From observations on those that are known to have lain in the soil a mere twenty to fifty years we may surmise that a 60-million-year-old specimen might appear as a rather ordinary concretion, if indeed it was distinguishable at all from its surroundings.

Why should meteorites not be preserved as well as organic remains which often are recognizable in the very oldest sediments? Organic fossils are identifiable due to their form rather than their substance, and since meteorites have no distinctive form any alteration in their composition and structure renders them less recognizable. Most pertified woods would not be easily recognizable except for the traces of cell structure or the forms of logs or twigs, and in many cases all trace of the cell structure has disappeared.

The moon is covered with thousands of craters which astronomers now generally accept as produced by meteorite impacts. These appear to be of all ages, some being fresh-looking and others so old that only traces of their battered forms can be detected. One wonders if our weather-troubled planet may have been equally battered and if the evidence has been erased by erosion.

Naturally, if crater-forming giant meteorites have been assaulting our earth, then others of small size also must have been pelting the terrestrial skin. We wonder again not *why* they have *not* been found but whether they *may have been* and have gone unrecognized.

Meteorites of even moderate age seldom are recognized by geologists and paleontologists who are the most logical individuals to be expected to report them in old sediments. Furthermore, the area of outcrops wherein fossil meteorites might be exposed is so infinitely small as compared to the soil-covered areas in which cultivation is likely to expose them that they could not with certainty be regarded as absent even had geologists been instructed in the art of identification and encouraged to seek meteorites as they hunt for rare minerals and fossils.

The record of billions of tons of coal having been mined without bringing to light a single authentic meteorite has been cited as evidence that meteorites are absent from the carboniferous formation.

Even well-preserved meteorites often are difficult to recognize when plowed up in ordinary soil until they have been well washed, and beause of the way coal is mined and sorted, it would be unlikely that even a fairly fresh meteorite could be singled out from the lumps of sulphide, concretions, slate and other waste that plagues the industry. Fairly fresh meteorites, of course, are not going to be present. Even after the most thorough scrubbing, and even though submitted to an experienced meteoriticist, it is questionable if a meteorite would be recognizable after subjection to the same metamorphosing agencies as have changed vegetation into coal.

If farmers working their fields by daylight fail to find meteorites until especially alerted, how could miners working underground or in the hurry of tip sorting be expected to distinguish between concretions and old, altered meteorites?

Geologists, paleontologists, even entomologists, could add to our knowledge of meteorites and to our representative collections of meteorites, during the regular course of their own specialized field work.

Dr. George Sternberg of Ft. Hays Kansas State College had been collecting fossils for thirty years when I asked if he ever had found a meteorite. He said that he had not. I coached him on the recognition of meteorites and within two years he found two meteorites while fossil hunting.

Amateur rockhounds perhaps are as good a source as any for problematical stones that may, when we know more about what forms to expect, turn out to be fossilized or altered meteorites. Very few of the old formations are accessible to view, but these are the canyon walls, cutbanks of streams and roads which rockhounds frequent.

The great majority of the meteorites that are recognizable on our planet may logically be assumed to be in a state of nearly complete terrestrialization. Two of the very few completely oxidized siderites recorded on the entire planet have been found in the state of Kansas with an area of less than one-sixth of one per cent of the land surface of the earth—a strong argument for geologists to be on the alert in other areas. An important problem that faces the geologist is the development of means to trace the final stages of terrestrialization so as to make possible the positive identification of the remains of meteorites.

Throughout geological literature there has been recognized the recurrence of geological revolutions—periods of world-wide readjustments in the earth's crust. The fact of such great changes seems to be well established, but there has been no adequate explanation of them.

The little planetoid Hermes missed our planet by a few hundred thousand miles in 1937. In May, 1942, in a brief article, "Cataclysm and Evolution," published in *Popular Astronomy,* I proposed that perhaps in the past such encounters had not always been near misses. I suggested that collisions with planetoids might explain geological revolutions:

> . . . it is not at all improbable that the Earth bears many scars of far greater dimensions than the largest known meteorite craters. Ten chances to one, these scars are concealed by water, jungle, desert, or arctic wastes, so that civilized man has never come upon them. . . . There are of course a thousand chances to one that all of the encounters occurred too long ago for the scars to be preserved down to date.
>
> It seems that we have here an adequate explanation of those successive revolutionary movements in the Earth's crust that are so generally recognized as having taken place, and also of the sudden blotting out of the fauna and flora of certain great areas which the fossil records suggest. ... If the dimensions of the lunar craters are to be taken as any indication of the sizes of the bodies that the Earth has encountered, then there must have occurred great changes in the shore-lines, the elevation and depression of extensive areas, the disappearance of low-lying land masses, the creation of islands, the extension and withdrawal of seas, as well as widespread and protracted volcanism. Violent climatic changes would have resulted, locally at least, from the heat of the impacts and from changes in the content of the atmosphere. More general changes might have resulted from a possible shifting of the poles, in the cases of the largest impacts. These changes would have necessitated faunal and floral readjustments. Species would have disappeared and new ones would have developed to take their places. Changes in geographical range would have brought about new adaptations, and we should expect, in general, just those breaks in the series that are actually found in the rocks.

My brief paper provoked little attention. Over the course of the years I made quite an effort, both in print and in conversation with scientists, to convince geologists and astronomers of the importance of meteorites to both sciences.

During the thirties I had done some experimenting with high-power rifle bullets in the formation of craters. To represent the stratified earth I used alternate layers of sand and plaster of paris. The contrasting colors and different textures enabled me to more readily detect the nature of the results of a shot. I gained some pretty clear notions of how the earth's crust must respond to a large impact.

I became convinced that all of the lunar features were the result, directly or indirectly, of meteortic bombardment. This idea was mulled over in my mind for a decade before in March, 1943, in a paper for the *Scientific Monthly* entitled "Meteorites and the Moon," I argued strongly for the meteoritic origin of all lunar features. I also proposed that cometary encounters "may well be considered as having been responsible on the earth for the puzzling succession of geological revolutions. . . . "

I argued the proposition that large meteorites are a factor in dynamic geology more forcefully in "Geological Significance of Meteorites," published in the *American Journal of Science* in February, 1948. As originally drafted soon after the appearance of the "Cataclysm and Evolution" piece, this was a much more elaborate treatment of the part cosmic collisions have played in the earth's development than eventually appeared in print. I had sent it in to the *Journal* but it was returned on the grounds that I belabored geologists too much for conservatism. I filed it away, then after the epochal fall at Sikhote-Alin in Siberia in 1947 I re-submitted a modified version and it was published by the very same journal that first rejected it. Before its appearance Dr. Harlow Shapley, who I assumed must have read my manuscript, wrote to me to suggest that I read a recent paper by Dr. Reginald Daly on theVredefort Structure of South Africa, published in *Journal of Geology,* Vol. 55, (1947). I sent for a copy. Here Dr. Daly described just such a feature as I had hypothesized as being responsible for small crustal movements in the process of mountain building. This was a major step in paving the way for an acceptance of the collision explanation of geological revolution. More recent proof of the correctness of my contentions has been accumulating through the notable field program of the Canadian Department of Mines and Special Surveys.

In my *Journal* article I admitted to having often been regarded "as somewhat of a radical in respect to meteoritical questions," and added that in my "most reckless moments" I had not been prepared to recognize such a rate of encounter with large meteorites as was indicated by the two Siberian falls of 1908 and 1947. I considered the significance of large stony masses that are disintegrated by the atmosphere and so do not form craters in most instances, as well as large-scale collisions.

> . . . For example, the Pasamonte, New Mexico, fall. . . left a cloud of dust aggregating about 1000 cubic miles which was formed at elevations ranging from 17 miles to about 48 miles. 1000 cubic miles of air at 30 miles elevation represents a weight of about 3,000,000 tons. Only a few small stones from this fall are known to have reached the earth, but their texture is such that they may be rubbed away with the fingers.
>
> The mass which invaded the atmosphere on that occasion must have comprised many thousands of tons. And had it been one of the firm varieties of meteorites it would have doubtless formed a considerable crater. But 17 miles of atmosphere lay between the level of its

> disintegration and the soil of the earth. This tremendous shock-absorbing cushion robbed it of nearly all of its violence. . . . There are very good reasons for believing that in space Pasamonte was a greater meteorite than that which the Russian scientists now report landing in southeastern Siberia and possibly also larger than the fall of 1908 which was estimated at 40,000 tons.
>
> Had the Pasamonte meteorite been of a metallic variety or even one of the more resistant stony varieties, it might have formed a sizable crater. As it was, all we can prove is that the massive cloud was formed in the upper atmosphere and that a few small stones were strewn over a strip of soil 28 miles in length. But almost certainly an enormous tonnage of minute particles were deposited over a much larger area.
>
> The important point that we are trying to make is that here is a process, cosmo-geologic in nature, that must have played an important role in the history of our planet.
>
> . . . it seems inevitable that large scale collisions have occurred throughout geologic time. The moon shows effects which can best be explained in terms of such collisions. On our planet where continents float on a more or less fluid sub-stratum, large scale collisions would logically initiate great continental movements such as are believed to have taken place during the various geologic revolutions.

In 1949, in his book, *The Face of the Moon* (University of Chicago Press), Dr. Ralph B. Baldwin suggested the magnitude of the effects on earth of impacts of bodies from space: "Written in the book of geology in still obscure characters are the records of hundreds of thousands of collisions of the earth and extra-terrestrial bodies."

The book *Target: Earth,* by Allan O. Kelly and Frank Dachille, published in 1953, in Carlsbad, California, went all out for "collision geology," but it was not well received; indeed, it was simply ignored. I believed and still believe *Target: Earth* to be a great book that will mark the beginning of a new epoch in the study of geology. Today, the principal theme of the book is being argued in the best journals.

Our earth shows only a few recognizable scars to mark the points of our collision with masses too large for the atmosphere to effectively brake their speed, but we are beginning to learn more of such great pockmarks as space probes begin to photograph similar damage done to the moon and the planets.

# 9. PLATEAU

The arrival of World War II meant an end to the kind of work I was doing, apart from my curatorship at the museum. Like everyone else, we lived on news, anxiety and hope for an ending. Gasoline and tires were unavailable for anything but essential contribution to the war effort. Rationing ended the freedom of movement, spur-of-the-moment investigations and extended travels on which my harvest of meteorites mostly had depended. For a time I worked as a salvage investigator for the War Production Board, combing the back country for salvable metals in the old mine towns, along the abandoned rail beds and where machinery lay disused in farm lots. I managed to enjoy scouring the mountains for old, disused railroad tracks, or swinging across some once rich canyon in an old ore bucket to see what piles of rusting iron might remain at a broken shaft or mill. Later, I found challenge in oil exploration, working in and out of Denver and Albuquerque, going on into the developing southern New Mexico fields to assess possible locations and negotiate for leases. With our youngest away in college, Addie joined me and we set up a temporary home in Artesia, New Mexico.

Although the work was full-time, this meant usually an eight-hour day or forty-hour week. This left a good deal of time for off-hours meteorite work, because I always had been accustomed to working sixty to seventy hours a week when self-employed.

It was my habit when traveling in the arid Southwest to carry fruit and sandwiches, or cheese and crackers, for lunch along the way. I would take food in hand and stroll about, scanning the ground for meteorites. For some twenty years I had done this off and on without results, but I felt that every effort thus made decreased the mathematical odds against my finding something.

On May 17, 1944, I stopped for a supper break at about 6:00 **P.M.,** approximately forty-nine miles south of Albuquerque, New Mexico. The site is near Bernardo and is recognizable by the overhead structure of an old-style bridge over the Rio Puerco, where it then was crossed by a former roadway of U.S. Highway No. 85, now modernized and re-routed. The area is wide-swept, sandy, flat, almost bare of vegetation but sprinkled rather generously with water-worn stones and small dark pebbles.

I had eaten, washed in the river and was about to return to my car when my attention was attracted by the end of a small dark pebble protruding through the sand; a pebble that was similar to, but perhaps not quite like the others scattered about that had been the cause of luckless and almost constant stooping for the past thirty minutes.

I nearly passed this one up, then bent my protesting back once more. When I loosened the pebble from the soil I saw at once that it was a small stony meteorite—a new one for the record books, since there was no previous report of a find anywhere in that region. It had a reasonably fresh appearance, the crust bearing some rust spots and stained by the soil to a dark brown rather than black appearance.

Finding of this little aerolite, named *Puente-Ladron,* the size of a small pecan and weighing less than eight grams, was one of the great thrills of my life. I had found other meteorites, but this was the first of only two that I came across in the course of my habitual scouting wherever I might be, and in areas where no meteorites previously were known to have fallen. About ten years later, in a rock-strewn field near Cottonwood, Arizona, **where** I had walked out to examine some unusual piles of boulders, I picked up a two-pound stony meteorite, the shape of a blunt cucumber.

No further specimens have been found at either of these locations. Because I believe that no stony meteorites penetrate our atmosphere unbroken, that they all must shatter, I am sure other stones remain to be found of the *Puente Ladron* and Cottonwood falls.

On a warm day in 1943 I became thirsty while driving near Wilmot, Cowley County, Kansas, and as I passed a farmstead I noticed between the house and the barn an old-fashioned hand pump with a tin can hanging from it.

Without bothering to go to the house I went to the well and pumped a canful of water. I was enjoying its cooling effect when I noticed a few steps away, beneath some plum bushes, a rusty-looking stone. With my thirst attended to, I stepped over and picked it up. It was an old, weathered stony meteorite.

I approached the house and knocked. The man of the house was not at home, but I showed the stone to the lady who came to the door, asking if she knew anything about it. She appeared puzzled that I should be interested in such a homely object. I told her it was a meteorite and asked if perhaps her husband had spoken of it. She said that he had not and she was sure he was not responsible for its being where I found it, for they had rented the place only recently.

I asked to buy the stone, but she insisted that I take it along if it was of any use to me. I gave her $5 for it.

In Bethune, Colorado, in 1941,1 recognized three meteorites mounted on a cement wall in a rock garden, and I found the Abernathy, Texas, stone in a rock garden while searching for meteorites of the Plainview fall.

Other meteorite finds that I made personally were at such sites of prior discoveries as Beardsley and Haviland, Kansas; Plainview and Odessa, Texas; Holbrook and Canyon Diablo, Arizona, and Xiquipilco in Mexico.

2

Just prior to the outbreak of war, a boyhood friend sent to me some meteorites of a fall in 1938 at Pantar, Lanao, Philippine Islands, which he had witnessed. He and his wife then were interned by the Japanese until early 1945.

Herbert J. Detrick and I grew up on farms not far apart in Oklahoma. Herbert was graduated somewhat earlier than I from McPherson College, and had gone to teach in the Philippines in 1908. I followed his career over the years as it was detailed in the college alumni bulletin. He and his wife, Lula, both were successful teachers. Herbert was named supervising teacher and assistant to the governor of Nueva Vizcaya Province, and became governor of the province of Palawan in 1915. Later he managed a large plantation and engaged in mining and lumbering, and in 1939 he opened a hotel in Dansalan, Lanao, Mindanao Island.

On the sunny morning of June 16, 1938, the rice stood lush and green on the hills of Lanao, and the people of the province went about their usual business; storekeepers opened their doors, housewives instructed their cooks for the marketing; students scurried to their classrooms and the native Moro farmers bent over their rice fields.

Suddenly there were strange explosive sounds from the sky, and then an object was observed for at least two minutes as it came from the east, emitting ringlets of smoke, and then ended its passage with a violence of explosions and vibrations and a spreading dark cloud that persisted for more than a half hour.

Excellent photographs of the cloud were obtained. At the village of Pantar, the Moros in their rice fields saw more than the smoking object and the great cloud; they saw fiery objects with tails of smoke shooting out from the cloud and many small objects actually fall into the fields, from which sixteen meteorites were recovered later from depths of up to twenty inches. At the same time, a pattering like hail sounded on the galvanized-iron roofs of several houses in the neighborhood.

I read in the news accounts that Detrick was tracing down and collecting the meteorites of the Pantar fall. I wrote to him and was surprised to receive the reply, "Believe it or not, I've been collecting these stones for you." He, too, had been reading the alumni bulletin. I sent him instructions as to how and what data to gather with the stones and for a year or two he worked in his spare time, surveying, drawing maps, collecting specimens. When finally he sent me his collection of thirteen stones not long before Pearl Harbor, he instructed that I do as I pleased with them, keeping what I wanted, selling others if I wished.

After Pearl Harbor, when it was evident there would be invasion of the Philippines, we decided simply to hold the Pantar meteorites in safe storage. We had no word of the Detricks' fate. When the Islands were liberated by MacArthur, still we learned nothing except that people of the Pantar area had been imprisoned. Finally, in the summer of 1945, we learned the Detricks had been interned in Los Banos prison and had been freed in February, 1945. They returned to the United States nearly broken, emaciated and destitute. Now we proceeded to sell their specimens to help tide them over until they received partial settlement for their holdings in the Islands. In appreciation, the Detricks added to our collection a representative from the Pantar fall.

5

The close of World War II meant a time for decision. My job with the oil company was at an end. After an interruption of four and one-half years, we were ready to go back to meteorites full time. Addie and I had made up our minds to leave the museum in Denver before I entered into wartime occupations, but our plans, like the individual hopes of everyone else, had been set aside until war's end.

J. D. Figgins, who as director of the museum had arranged the terms of my curatorship with the museum's board of trustees, had a high interest in meteorites. Figgins had served as Admiral Peary's right-hand man on the three expeditions by which were recovered and transported the three great Greenland meteorites put on display at the Hayden Planetarium in New York. During Figgins' leadership the museum participated in a number of my field projects. This arrangement, during a period when my field program brought forth more meteorites than were being found by all other institutions throughout the world, rewarded the museum with a rapid growth in its own collection. Dr. Figgins retired in 1936.

His successor was Dr. Alfred M. Bailey, whose scientific and field interests lay in other lines. Under the stewardship of Dr. Bailey, the Denver museum, already recognized as one of the finest and most beautiful in the country, expanded and improved. Also, its emphasis shifted somewhat in reflection of his interests as one of the leading bird men of the country and a respected collector of bird and mammalian exhibits from many parts of the world. I was invited to stay on as curator but otherwise the museum was not interested in further participation in my field program.

Other than such support and assisttance as we had received from the museum, our work had depended on a host of friends.

"If you ever get into a tight spot, come to me. I can always raise a little cash."

Many a man had said that to me, and meant it. I never was a good beggar, however. In fact, I never at any time felt I could accept outright gifts, much less ask for them, unless they came from established foundations which existed for the purpose of supporting work such as mine. And when it came to foundations, I was not very successful. Time and again I had applied for grants, with rare success, and never receiving more than very small sums.

Now I was fifty-nine years old. It seemed important that in our return to an independent course of action we should be assured some continuity, and some security for declining years, without the constant harrying necessity of funding and re-funding as field projects presented themselves. In the last years before the war, cost of our program had grown to between $4,000 and $5,000 a year.

We were the owners of one of the world's greatest meteorite collections. It had been amassed with a single purpose: that finally it should be devoted to the advancement of knowledge through research and education. We had never discussed the possibility of turning the collection, in entirety, into cash, except that we viewed it as our "life insurance" against emergency and old age. But we were determinedly opposed to accepting the kind of poverty-ridden, handicapped existence which we had known some scientists to have been forced to accept from institutions as recompense for various kinds of natural history collections and researches.

We had observed that great institutions have a way of persuading, virtually coercing men of achievement in lines of natural science to donate priceless collections for the "honor" of having bestowed them. Then the names of the donors are modestly displayed on labels of the exhibition cases to pass unnoticed by any but specialists of the same field, while the building which may house the life work of a dozen devoted scholars bears emblazoned across its facade the name of one who may have donated a small fraction of his income.

Finally, Addie and I believed, we hit upon a means by which our collection and our knowledge of meteorites, for which we had been unable to obtain any institutional support, would provide our living with enough surplus to continue a research program. We would provide our own institution.

For more than a decade we had thought longingly of living near the great Arizona meteorite crater. Now we decided the time had come for such a move.

This greatest of known meteorite craters, represented a deficit of an estimated half million dollars to its owners. Barringer and his associates, with commercial mining as their objective, had made extensive explorations during the years from 1909 to 1931. After the failure of the commercial venture, none of our nation's great research or educational institutions had made so much as a casual survey of the crater. The University of Arizona never had published more than a cursory description of the feature nor sponsored any kind of survey.

Attempts I had made in 1939 to measure and map the distribution of small metallic fragments on the surrounding plain had suggested that further researches could produce significant results. One delegation headed by W. T. Whitney of Pomona College searched for meteorites shortly after our work was ended, but nothing of importance was reported.

This state of affairs seemed an invitation to move our collection into the area, where it could serve the dual purpose of educating the traveling public and providing a base for further researches.

It was not the garish signs and gaudy tourist traps of Highway 66 that attracted us. Our interest lay in the proximity of the Meteor Crater and its emphatic testimonial to the effects on this earth of stones from space. Our institution would be a Meteorite Museum; nothing else, just meteorites; no snakes, no skeletons, no stuffed birds, no wild animals and no curios—just meteorites.

It would be the first and only museum of its kind and it would be run on a high, educational plane. Not only would we put on public display our collection, one of the greatest in the world and unique in some aspects; we would present it in as effective a manner as we could devise and accompany the exhibit with educational lectures that could not be duplicated in most geology and astronomy departments of our finest universities.

Addie and I decided to take our trailer to Flagstaff* and spend the summer of 1946 there while we looked around for a location for our museum before actually moving the collection.

The crater, owned by the Barringers, rises from the midst of a cattle ranch owned by the Tremaine family. Interspersed among sections of land owned outright by the ranch are sections of state land on which the Tremaines have grazing rights. For years the Barringer family had been friendly. The crater owners offered no financial assistance but asured us verbally of close cooperation. Freedom to search for and collect meteorites on the Barringer property always had been extended. Now when we presented our plan to locate near the crater I again was invited to search and collect freely, although I was assured that almost all of the meteorites were gone by now.

"Keep whatever you find, unless something of ten pounds or more turns up in which case we should like half. We like to keep a few pieces around to show or give to friends and we are getting pretty low on them now."

In practice, we divided all specimens we recovered on a basis of weight, a fourth going to the Barringers.

By April of 1946 we had been in touch with the Tremaine group also and had been given permission to undertake an extensive survey for which funds again had come from the American Philosophical Society, which had contributed $250 toward the $1000 cost of the 1939 research.

We settled in our trailer under tall Ponderosa pines at the foot of Mt. Elden, east of Flagstaff. Our younger daughter, Margaret, finished college in June and decided to spend the summer with us. We had a grand time, frequently visiting the crater and searching for small meteorites, under terms of our written permission from the Barringers' Standard Iron Company and our verbal understanding with the Bar T Bar ranch. The search was tedious and not very rewarding at first, but gradually we became more efficient. Margaret found the largest specimen we recovered that summer—a two-pound iron that she pulled excitedly from the soil by one protruding corner. Any recall of that summer brings to my mind a picture of Margaret, on her knees, digging like a dog after a ground squirrel. She had called to us, but couldn't take time to look up from her digging. She had found an iron of several ounces in a little ditch and by scratching uncovered a larger one and then a third, as I remember. She had the best luck of the day, and of the season for that matter. We became so enthralled with the search that we made many trips to the crater, a distance of forty miles. Each of us carried a magnet mounted on the end of a cane. By this means we could test an object without stooping to pick it up. If it clung to the magnet it was either oxide or a metallic meteorite. The oxide was meteoritic also but had been altered through weathering. The oxide chips were many times as numerous as the metallic fragments, or "irons."

All in all, we collected about ten pounds during the summer, mostly of the order of a tenth of an ounce in size. When I reported to Brandon Barringer, he merely shrugged.

"Keep it!" he told me.

We were maintaining records of the sizes and distribution of these small iron meteorites about the rim and extending plain. Later in the summer, Ab Whelan, who had performed magnetometer work for me in New Mexico, came from Artesia to conduct a magnetometer survey in the crater environs, a project that unfortunately was never completed and that gave no definite indications of remaining large masses under the soil.

Prior to the war we had discussed with members of the Barringer family our hope of moving into the area and had talked of establishing a museum on the very rim of the crater on some kind of partnership arrangement. We could not seem to convince them that the plan was workable, but in the summer of 1946, when further discussions were undertaken with the Barringers, and with spokesmen for the Tremaines' Bar T Bar ranch, which surrounded the Barringer property, we were surprised to learn that their planning had progressed to the point where architectural sketches had been prepared for a building of striking design, hanging over the rim and balancing inward over the crater bowl. Signs and circulars had been prepared.

Burton Tremaine and I laid our cards on the table. He warned that they had the capability of going into the business alone and driving us out since they had the power to outdo us in advertising and could set up a larger institution. I pointed out in turn that it would be impossible for them to obtain another collection like ours and that our museum would in no way compete with or obstruct their tourist trade.

From our point of view, the meeting ended on a note of encouragement. We felt that now we were in a position to go ahead independently or cooperatively, but we had full confidence that once having proved ourselves we would be offered a permanent place in the plans for the crater rim. However, a divergence of views arose and eventually we went our separate ways. The Barringers and Tremaines operated for a time much as in the past, but ultimately built a handsome structure at the crater, where their lure to tourists was a closeup view of the meteor crater. They hoped to derive income which would support further exploration for the great mass they still believed to lie beneath the earth.

By the end of summer of 1946 we had leased a building on Highway 66 and were ready to establish our museum, where our appeal was to persons interested in learning something about meteorites by exposure to a fine collection and educational lectures and materials.

# 10. A NEW LEASE

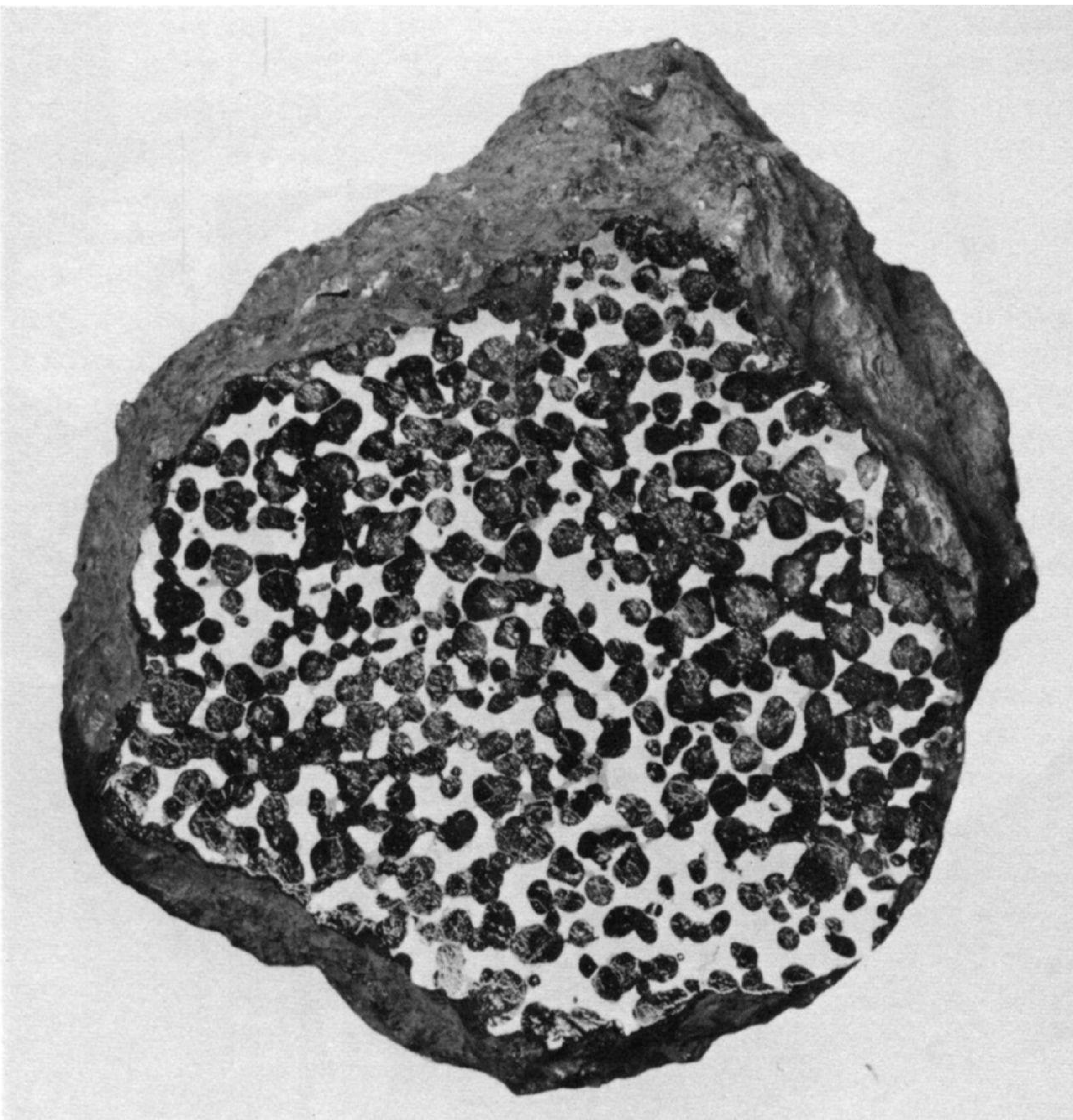
The building we leased on Highway 66 was situated on a small bluff just off the highway, looking across to the crater from a distance of five and one-half miles. It constituted a sort of landmark in itself. It never was beautiful, at least not to my thinking, but it is an interesting structure, faced with natural flagstone, with a heavy square tower jutting against the sky. The building still stands, lonely and deserted, a watchtower of rock in a rocky desert.

Prior to our taking it over, the building was known commonly as "the Observatory." Tourists climbed its tower for a "view" of the crater—which could be viewed just as well from its front porch. From neither point could one see *into* the pit. Curios were sold; and a dingy, crude, plaster and chicken-wire mock-up of the crater purported to bare the secrets of its creation and the cache of iron treasure supposedly in its depth.

Although I have heard others describe the building as beautiful, to me it remains an architectural monstrosity, but there can be no question as to the beauty of its location on a low hill above a nearly level plain dotted with grotesque shapes formed by nature from the same red sandstone that provided its walls.

We could look west through large picture windows forty miles to the San Francisco peaks, the highest point in Arizona, and a host of smaller purple hills and mountains. To the east, if we stepped outside or climbed the tower, we could gaze toward the volcanic plugs and colorful mesas of the Painted Desert lands thirty miles away. Just a few miles to the south rose the rugged rim of the mile-wide meteorite crater, described by one of the wisest men of Europe, the great Swedish chemist and physicist, Svante Arrhenius, on a visit in the early 1900's, as the most interesting spot on earth.

The fact of the crater's presence was our reason for choosing the location. Most probably there never would have been a meteorite museum



*Polished section of a stony-iron meteorite found near Springwater, Sask., Canada. The white irregular bands of nickel-iron envelop crystals of olivine.*

*Dr. Nininger explaining meteorites to visitors in his museum, Highway* 66.

had there not first existed the meteorite crater. We felt that we could do without police protection. We could do without neighbors. We could get along without society and entertainment. Our location pleased us, but left us no choice. We had to get along without many accepted features of civilization.

In about 1930 or 1932, when its situation was even more isolated, our building had been erected by the bare hands of one white man and the help of some local Indians. The floor was laid with flagstone and although it was a little rough, I always thought it beautiful and practical. The walls were thick, but the native stone had been laid originally with the red mud of the hill on which the building stood. When the first heavy rain came, much of the mud washed out and the whole structure threatened to fall apart, whereupon its builder recognized his error and attempted to fill the resultant voids with good cement. This rendered the walls substantial enough, but additional labors never succeeded in making the structure waterproof, as we were to see later.

We signed our lease, parked our trailer in the back yard and arranged for expansion of the plumbing facilities to accommodate visitors. The landlord dug a well and installed a water tank. We cleared everything out of the building, polished our picture windows and hung new **Venetian** blinds across them. Then we climbed into our 1942 Chevrolet and headed for Denver to bring back our meteorites.

Our idea was big, our plans were big and our risks were large. As had been the case so often before we were striking out on an untried course. We had not heard of a museum of meteorites anywhere, much less one located on a lonely highway hundreds of miles from any heavily populated center and twenty and forty miles from the two closest towns.

We received no very great encouragement from any of our friends, though we were flooded with good wishes which might have been received more enthusiastically had they communicated conviction that our venture would succeed.

One friend of ours, in particular, an attorney, baffled me by his parting comment. Respected, successful, philanthropic in his interests, this man had helped me with free legal advice on occasion. Now he listened sympathetically to my plan and asked a number of pertinent questions. He offered assistance if it should be needed and said his final words in fatherly tones:

"Now, don't you let those people down there hurt you."

As I walked to the elevator I pondered his words, repeated them to myself, trying to accept his warning as a joke.

With or without bright forecasts of success, we had made the only choice we could see open to us. Once more we broke all formal ties and put our reliance on ourselves.

Dr. Bailey the new museum director expressed appreciation for my years of association with the Colorado Museum of Natural History, and directed his staff to assist in the arduous task of moving and loading our several tons of meteorites. Since the Denver museum was installing a series of new exhibit cases in the mineral department, Dr. Bailey kindly offered us some of the old ones that were being discarded, and these massive but usable pieces went with us to Arizona.

The moving of a 16,000-pound collection of meteorites a distance of 750 miles is no small chore. The packing required weeks of heavy labor. When eventually we loaded our collection into the moving van there were nearly two hundred boxes and crates, including two very heavy ones containing our two large stony meteorites, both of which were somewhat fragile. Hugoton weighed nearly 800 pounds before crating; Morland only a hundred pounds less. Then there were eighteen heavy iron specimens, weighing from 150 to more than 400 pounds. These were not crated and were in no danger of being damaged, but they constituted a real danger to everything else in the van in case of an accident, since any one of them, careening loose from a heavy jolt, could smash through any box or crate in the cargo.

Most important were the thousands of small specimens, some of which were worth several times their weight in gold and many of which were so fragile that we had wrapped each one and its label in several thicknesses of tissue or toweling or both, then again in a generous amount of newspaper before stowing them carefully in wooden boxes.

This cargo was the entire Nininger collection as of the year 1946. It had been gathered over a period of twenty-three years and had absorbed every bit of our life's earnings. Except for some elderly furniture, a middle-aged car and our clothing, it was literally all we had. So now all our eggs were in one basket, a trucking company's moving van, headed for a crude stone building 750 miles away on Highway 66, miles from city protections and services and without close neighbors.

To us, moving the collection appeared as risky as transporting diamonds or delivering bags of money. We had selected the transfer agent cautiously. The contract contained a clause requiring the cargo to be locked into the van in Denver, not to be opened until it reached the front door of our building on Highway 66. Insurance posed a problem because our cargo failed to fit any of the usual classifications. Coverage to the extent of actual monetary value was prohibitive in cost, and the monetary value was the least consideration. More important was the irreplaceable nature of the material. Since we couldn't raise money to cover the premiums anyway, we paid our thousand-dollar shipping costs, settled for nominal insurance and simply accepted the risk. Company spokesmen extended impressive assurances of competence and safety, we signed the agreement and started our life estate on its way. The company's estimate was that the truck would reach its destination twenty-four hours after starting time, traveling day and night with two drivers.

We agreed to be on hand to greet the van. We gave ourselves a head start and drove steadily in order to have everything in readiness for the unloading, intending to supervise that operation personally. The van did not arrive as expected at the end of the second day, nor did it arrive the third day. Anxiously we waited through another morning, scrutinizing each truck that approached from the east, watching it travel the considerable distance that lay within our view and sighing with disappointment as each passed on without pause. In the afternoon we decided to drive east to Winslow to seek word, not yet having a telephone.

We knew that van loads seldom are lost in transit, we hardly dared think of accident, yet fear was building that something had happened. About half way to town a sight loomed up a mile ahead at which our hearts fairly plummeted. At the side of the road was a wrecked van, headed in our direction, from which small heavy boxes were being transferred to a second truck. The wrecked vehicle carried the symbol of our transfer firm. We bore down upon the prospect of disaster, our thoughts racing. Had we only invested in insurance! How much of our collection would be salvable? What of the small fragile rare specimens—why had we not sent them by registered mail or by express? How much loss of labels and identification might there be?

Usually when some unexpected calamity strikes my mind works at its best, but as we approached that mess in the road ahead of us, I felt a little sick. As we pulled up and stopped, a man on the ground handed up a broken box to the man in the relief van. I could see then that the box contained heavy bolts and nuts.

The drivers showed concern for our problem, but they had no information about our truck. In town we could learn nothing. A call to the Denver office of the firm brought no satisfaction. There was nothing to do but return to our empty building and wait. All the next day we waited, almost in panic. In mid-afternoon, a van mounted our hill and backed up to our door. The van was not the same that we had seen loaded in Denver, nor was the driver the same. When the door was opened my heart sank again. Crates were broken, boxes we had stacked so carefully in such precise order were helter-skelter. The great, fragile Hugoton stone was half out of its broken crate. Some boxes were open. It was evident that in the shift to another truck things had not been handled carefully at all.

The driver had no explanation other than that all cargoes must be transferred in Albuquerque. He might as well have been hauling stove wood so far as concerned him. He shrugged. He only "acted on orders." And his orders were to deliver that truck in Los Angeles by morning.

"So let's get unloaded."

After I unloaded my feelings, we fell to unloading meteorites. Two men were to have accompanied the truck to handle the unloading, but there was only the driver and a small, 67-year-old Indian he had picked up as a hitch-hiker. There was no equipment to handle heavy pieces.

The Hokanson family, friends from Flagstaff, had driven out to visit us and for three hours Elmer Hokanson, the driver, the Indian and I, with assorted help from the ladies and children, worked until we had unloaded and carried inside some five tons of meteorites. In addition to all 189 crates, bags and boxes, we unloaded the several large show cases from the museum.

There remained about three tons of heavy irons, including one weighing 1,406 pounds that had been shipped without crating. These we simply rolled out of the van into the yard.

The unloading went fairly well, and as we approached the finish things looked brighter. The sky was brightening also. This was the evening of October 9, 1946, a notable date in the history of meteorites and astronomy for a reason more profound than the moving of our collection. All over the planet men were alerted for the earth's probable encounter with a swarm or stream of meteorites on this evening. The Giacobinnid-Zinner comet had passed eight days earlier, leaving a trail of debris through which our earth must pass. The Hokansons had planned to enjoy an evening of meteor-watching with us in the desert; the show already had begun during the final forty-five minutes of our unloading chore.

We were a wilted, tired lot when finally we spread blankets on the ground, turned our eyes to the sky and munched sandwiches the women had prepared. We appointed a timekeeper and began counting. The number of meteors per minute climbed gradually from twenty-six in a minute to thirty, to thirty-six, to forty. As the tempo of meteor flashes across the sky increased, we recorded counts of sixty, seventy, eighty. Once the count passed the hundred mark.

Although the majority were rather small there were numerous of first and second magnitude and some even brighter. We noted at least a dozen that were more than twice as bright as Venus at her best seasons.

The celestial display of October 9 was interpreted by us as a fitting prelude to the opening of our museum. And it could be said truthfully that some three tons of meteorites fell within view of our meteorite museum during the Giacobinnid-Zinner shower. It was quite an opening event.

Billy, the little Indian who had come along with the truck, weighed about 100 pounds and was about the size of an average twelve-year-old, but what he lacked in strength he made up with willingness. When it came time for the truck to leave he didn't want to go with it, and insisted on staying with us.

There we were, in the middle of a desert, and Billy's only reference was the driver of the truck that had brought him off the highway. The driver could not tell us much, but we could not very well get rid of Billy, or at least we had not the heart to, for he had worked well and asked nothing but shelter. We came to the conclusion that he could be of great help to us in getting our material unpacked and in order, so we let him stay. He proved to be a good worker. Things went along all right for Billy until a sign construction crew brought liquor onto the premises. This, it turned out, along with an inclination to dependency, was Billy's weakness.

The first days on Highway 66 were crowded with painfully laborious tasks of shifting, uncrating, lifting, unwrapping, placing, labeling, rearranging. My arms ached, for it seemed as though all 16,000 pounds of meteorites had to be moved two or three times before they found a permanent resting place.

Billy washed down the interior walls and painted them. The front veranda was stacked high with boxes for storage, the museum room was crowded with display cases and specimens helter-skelter, the living quarters were full of furniture waiting placement, dishes overflowed the cupboards and kitchen utensils cluttered the drainboard. The plumbers, who were to have finished the day after we left for Denver, still hadn't finished when we got back. Washbowls and toilets decorated the back yard. Our trailer seemed a haven of refuge.

Billy unpacked so many odds and ends of dishes and knickknacks that he shook his head.

"Why don't you live like the Indians, then you don't have so much work."

When he got a few dollars ahead, Billy caught a ride into town. For a time we knew nothing of him, but he returned later, only to disappear and reappear from time to time. Usually he came only to pay friendly visits. We would let him work if we needed him but never hired him again except on a day to day basis. Once he wrote from Oklahoma, explaining that he had been in the hospital, and asked for bus fare to Arizona. We sent him the money. He came, visited and went on his way. Again we had word from Denver, where he had given our name as his only friendly reference. We did as much as we felt was advisable for him or for us, but eventually lost track of him, holding only a hope that he prosper wherever he might be.

As soon as a considerable part of the collection was housed under glass we decided to open our doors. All the major specimens were in place except Hugoton, its 770 pounds still secure in a plaster jacket. The derrick and hoist were set up ready to finish the job. All the big irons from Canyon Diablo had been placed on a central platform where they made a fine focal point.

Visitors had been coming up the hill ever since we arrived, approaching our door or peering through the windows, and on October 19 we put up our little sign, "Open."

This was our first taste of serving the public, of being on the inside of the counter rather than standing outside to be served. We were to find that such service sometimes can grow tiresome, that some people can be rude, and that we could burn with indignation at actions we considered to be indignities. We never grew tired, however, of our basic purpose, to share the knowledge we had about meteorites in the hope that doing so would spur the growth of the science of meteoritics.

Our hours were governed by the presence or absence of customers, and by daylight, for as yet we had no electricity. As soon as there was good light we were ready to open; as soon as good light was gone, we closed, although occasionally we guided persistent guests by lantern light.

Our display room took up most of the space of our building, twenty by forty feet. The tower, with some storage space to the side, opened off one end of the room. Our living quarters were one room about sixteen by eighteen feet, with a tiny bathroom adjacent. Public restrooms had been installed in former storage space and opened to the exterior of the building.

We set up book shelves to partially separate our sleeping quarters from the kitchen. There was a small window on the west, at the foot of our bed, and another on the north, over the gas cooking range, which was fed by butane gas from a tank outside the window.

Evenings found us in our back room, cooking and eating and reading by kerosene or gas lantern. Our disconnected electric refrigerator was thrown on the mercy of the principle of diminishing returns as we brought cakes of ice the nineteen miles from Winslow on a hot day. Addie managed with old-fashioned sadirons, washed by hand or used the laundry service in town. Our only radio news was received on the car radio, which at times picked up a pretty good signal but was not dependable.

The first rain proved that the builder never had succeeded in replacing all of the red mud with cement. After every storm we had to go about with a shovel or dust pan and bucket and mop. There were always from six to a dozen places—not always the same ones—where mud piles accumulated. The most unsightly part was the walls. They had been plastered and we had painted them white so they might reflect as much light as possible for the exhibits. Now the muddy water which ran down the walls left glaring red streaks. With all of our efforts to stop the leaks we were never wholly successful. We would climb a ladder to plug a hole, but at the next rain one or more new leaks would appear. Most came where the ceiling joined the walls.

The rains did not bring our only problems. The winds often whipped our exposed hill unmercifully. Such red dirt as was not running down the insides of our walls in wet streaks when it rained was carried into the air and blown miserably about our refuge, pitting the paint on our car and trailers, sifting through windows. Snows, when they came, often were borne on cruel blasts of wind.

Winter could be very cold on Highway 66 and the summer, hot. Nevertheless, we nurtured a small oasis of Chinese elm trees and some cacti, and we thought our surroundings beautiful.

Coyotes sang regularly from nearby stations and our dog could chase rabbits any time she chose. We had other animal neighbors. One morning I came out after breakfast to unlock the front door. The mechanical cash register rested on a counter that ended against the wall about two feet to the side of the door. I undid the padlock and turned to go back when an odd, indefinite image of the cash register and the adjoining wall seemed caught in my memory.

The roof above the door was supported by a log pillar that branched at head height. Had I seen something strange there? I turned to look. Draped across the register keys and then spanning the two-foot gap to the fork in the log pillar, from where his beady eyes stared at me, was a huge bull snake. His tail dangled from the "Total" key about eight inches. I could not resist calling Addie to come see if there was anything wrong with the cash register. She did not appreciate the joke.

Once Addie met a large king snake on the tower stairs, and several times we dealt with rattlers. During one of Margaret's visits with us I had stepped outside the kitchen door as she and Addie returned from Winslow. They stopped the car just beside our dog Blondie's house. When Margaret opened the car door, Blondie rushed in between her and the little house, barking fiercely. Margaret was a favorite of Blondie and we couldn't understand the dog's action. Blondie wouldn't be persuaded to withdraw. She kept ducking her head under her house as if to sniff under it. Finally we were convinced that she sensed danger. We lifted the dog house and there lay two rattlesnakes. Blondie dispatched them furiously.

Some of the small but dangerous scorpions were found occasionally. When Shorty, a ranch hand, was replacing railroad ties that roofed our "garage-workshop" he came across numerous six-inch centipedes. When we left the desert after several years to move our museum to a new building in Sedona, in Oak Creek Canyon, the last farewell was given by a rattlesnake flashing its head in and out of a chink in the flagstone wall just opposite to the doorknob of the kitchen door as we were ready to lock up for the last time.

Half the tourists who drove up our hill would read our little sign listing admission fees of twenty-five cents for adults and fifteen for children, then turn and leave. Some would only look from the car and then drive on. Some would drive in, around the building and out without stopping at all. A few would come in without reading the sign and then stalk out when fees were mentioned.

In spite of this, the number of customers our first day totaled sixty, and most seemed well pleased. Admissions increased steadily, over all, though there were occasional days when the number would drop to a dozen or less. Once in a while the number surpassed a hundred.

As spring opened up the flow of traffic increased and the hours of daylight lengthened. We were encouraged enough by our volume of admissions and by the additional income brought in through sales of literature and specimens, both to museum customers and by mail order, to decide that we could afford to hire help. The seven-day weeks, with lengthening hours, were beginning to tell on us.

We offered jobs to George (Don) Thompson of Denver, and his wife, Ruth, whom we had known for years as the son and daughter-in-law of our late friend, Art Thompson and his wife, Miz. Don and Ruth joined us in April of 1947 and set up housekeeping in our twenty-two-foot trailer.

Ruth helped Addie with the bookkeeping chores. We all shared duty as museum guides and lecturers, although I carried the burden of the latter. Don, in addition to museum duties, performed shop work. Like his father, Don was handy with gadgets, and he brought a mechanical aptitude which was sorely needed in our situation, located as we were miles from any city services and parts suppliers.

We had a gasoline-powered water pump to worry about; plumbing, which suffered sometimes at the whims or carelessness of tourists; cess pool; parking area to keep clear and provide with barriers; butane tanks for cooking stoves; oil tanks for heating stoves; and the cash register to keep in running order. My method is to attack things mechanical with dogged determination and any tools I can lay my hands on, but without much natural talent. So Don's aptitude was welcome and, so far as was feasible, mechanical chores fell to his lot.

Don and Ruth studied hard to master a practical knowledge of meteorites and the most effective means of presenting that knowledge to the public. The facts about meteorites are themselves so interesting and unusual that an accurate portrayal is all that is necessary to attain the objective of interest.

The visiting public included many and varied personalities. Some brought weird and sundry stories concerning meteorites that would at once be recognized as honest mistakes. A sense of humor was required to deal with some of these in a way that would correct the error without offending the customer.

In the museum, a visitor could heft in his two hands a piece of matter from outer space. He could himself touch and wonder at these particles of matter that a scientist can weigh, can analyze, can study, and from which he can gain information just as significant as that the astronomer gains when he catches in his telescopic lens light that has been on its way to earth for hundreds of millions of years.

Frequently we received groups of touring school children or older students. We quickened the youngsters' interest by inventing "treasure" hunts with clues by which they could locate particular displays or specimens. Often our visitors included scientists of note, many of whom I had corresponded with or dealt with in the past, but some of whom I met first through our museum. Often, former students from the various colleges where I had taught would stop to view the collection and to visit.

Once in a while it was difficult to draw the line between "paying visitor" and "guest," but most of our friends recognized that we were in the somewhat perilous business of making a living by exhibiting our collection and they supported our endeavor while they brightened our days with their visits.

The closing of books the first twelve months of operation showed more than 33,000 paid admissions. The visitors represented every state in the Union and forty-three foreign countries. There had been classes from fifteen colleges and high schools, a few groups of scientists and several other miscellaneous travel groups. We had distributed more than 5,000 books and pamphlets.

Three- to five-minute lectures were presented throughout the day. Additional attentions—often half-hour lectures—were afforded to groups or particularly interested visitors. At invitation, I had spoken before numerous schools and clubs in neighboring Arizona towns.

Casual mention one day of a fireball the evening before brought reports from two parties present in the museum who had witnessed the same fireball from 300 miles apart, one headed west and the other east. Thus, quite by accident, we discovered that our location was well suited to receiving reports on fireballs. We would post a bulletin and could expect additional reports from visitors within a few hours.

Our museum was small, the collection large. It was organized to include illustrative exhibits to demonstrate seventeen aspects of meteorites and related phenomena:

1) Classification. We were able to display most of the eighty known varieties of meteorites.
2) Surface features and problems of air resistance at high velocities.
3) Structure of stony meteorites and their bearing on the origin of meteorites.
4) Structure of metallic meteorites as related to chemical composition and possible bearing on origin.
5) Shapes of meteorites, with 3,000 specimens available for study by interested researchers.
6) Disruption of aerolites during flight and effect on total weight of annual accretion.
7) Approximate frequency of "shooting stars."
8) Distribution of meteorites of a shower and significance relative to magnitude of parent mass.
9) Nature and cause of disruptions.
10) Relation of depths of penetration by various members of a shower.
11) Average probable composition of meteorites in space relative to fireball phenomena, arrival on the soil, and in comparison with composition of the earth.
12) Meteoritic oxides and their importance to astronomy and geology.
13) Lunar craters and meteorites.

14) Lunar craters and tektites. (strange blobs of glass that are found only in certain locations on earth and whose origins still are in doubt.)
15) Ballistical implications in the forms of certain meteorites.
16) Influence of meteorites on the lives of primitive peoples.
17) Meteorite craters—their present known distribution, the probable abundance of concealed craters, their geological significance and relation to regional mineralization.

One day a man stepped to the cashier's window and with a skeptical expression paid his admission, then came inside. He glanced about, read several of the monitor cards posted on the walls, examined the case nearest him, then turned to the desk.

"I'd like to call my wife who is out in the car. It is evident you have something worth while here."

The two of them examined the displays. Finally the man turned again to me.

"Is this a state-supported or government-supported institution?"

I told him that it was privately owned, privately operated.

"Well, how was such an enormous collection ever assembled?"

This question, for which an answer involved some brief resume of the story of my life, came to us repeatedly during the fourteen years we operated the museum.

In only three cities of the United States were comparable exhibits to be seen—Chicago, New York, and Washington, D.C. Even in these great institutions—The Field Museum of Natural History in Chicago; the American Museum of Natural History; and the United States National Museum—there were no similarly extensive presentations demonstrating significance, distribution, varieties, surface features, effects of weathering; nor was there a competent guide to explain and answer questions.

I fully understood the visitor's puzzlement. From only a slightly different angle I had puzzled over the meteorite problem thirty-five years before. Only what had puzzled me was not the presence of a great collection before me, but the lack of such a collection in any of the institutions wherein I had studied or taught.

Aside from light, meteorites furnished the astronomer, during those years, his most intimate contact with the universe surrounding our tiny planet. Yet a man might have earned a doctor's degree in astronomy in almost any American university without hearing a single lecture or reading even a chapter on the subject of meteorites. Meteorites constituted the sole material evidence of the *modus operandi* of earth growth, yet one might earn a doctor's degree in geology without ever learning even to recognize a meteorite in the field or laboratory.

This situation was only to some extent ameliorated by Sputnik.

We were convinced that in putting our collection on public view and charging a fee we were serving a purpose beyond our personal needs for self-support; that we were fulfilling an educational function. During each year of the museum's operation more hours of instruction were given to more people on the subject of meteorites than were given on this subject in any university in the land. There was no other institution where an individual instructor was devoting his entire time to the subject of meteorites.

But on Highway 66, stretching across several states with one "gyp" joint after another, where the gullible paid a quarter, a half dollar or a dollar to view faked cave dwellings, stuffed animals, or snakes or gila monsters that he could view as well in public zoos, it was hard to convince many visitors that here was not just another house of the same ilk.

One man who drove up with his family turned away when he saw there was an admission charge. When I asked him why, he replied in effect that I had no right to charge for an exhibit advertised as educational.

"Education in our country is free," he stated.

Of course, he was mistaken. Education is not free. It must be paid for through taxation, endowment or in some other way. The fact that it is provided on a theoretically equal basis to all children does not make it "free" in actuality. The burden is spread in some way among taxpayers. The great museums of our cities, the art galleries, the botanical gardens, all are paid for in some manner. The fact that one enters without an admission charge does not mean that the institution is operated without cost. It is supported either by tax money or by gift. Some of the great museums charge nominal admission fees which represent only a small fraction of the cost of operation.

Schools have not always been tax-supported. There was a time when pupils paid fees for the privilege of attending classes, when the teacher collected his salary or wages directly from the pupils he taught or from their parents. The establishment of a tax-supported school system followed realization by the public of the importance of education to the general welfare.

In grandfather's day no one thought of studying music, painting or subjects other than the three R's in the public school. For them he had to obtain and pay a private teacher. Gradually, as the importance of these other studies was realized, they, too, were added to the curriculum and paid for out of the taxes of all of the people. But before this could happen someone had to pioneer in the teaching of these various subjects in order to demonstrate their importance.

When I first became interested in meteorites in 1923 the principal sources of information were a few great collections in tax-supported museums and technical papers not readily available. In the process of studying such collections and literature as I could find, I acquired a desire to see something done to bring this aspect of our universe to the public. I learned that people who had opportunity to handle meteorites, or who had witnessed their fall, had a great yearning for knowledge concerning these lumps of rock and iron that occasionally plunk themselves down on our earth. When I could not find an institution to support such an aim, I did what I conceived as the next best thing. I set up my own museum, and since I couldn't levy taxes, nor establish an academic course and charge tuition, I imposed admission fees, feeling not much different than I had during the sixteen years when I taught in colleges or universities and went monthly to the business office to pick up my check.

2

When I was combining study with teaching at McPherson College, a lad used to hang around my laboratory a lot, out of a burning interest in the work we were doing with bugs and birds and small mammals. He hung around so much that sometimes he got a little in the way, but he was a likeable kid and one day when he was underfoot I tried a diversionary tactic.

"Take this reading glass and go out and study that ant hill there in the yard," I told him.

The task so interested him that he spent most of the rest of the day on his knees, glass in hand, watching the comings and goings of those tiny communal creatures.

That boy was John Hilton, the now noted artist, naturalist, author. The Hiltons moved from McPherson not long after my first acquaintance with John, and I didn't see him again until many years later. By then he had made his name in the artists' and writers' world, and when I read one of his articles in the *Saturday Evening Post* I determined to look him up, wondering if he was the youngster I'd known in McPherson. In 1938 we visited him in his desert studio in California.

"You know," he told me, "you are responsible for all of my interest in science." And he reminded me of the ant hill.

John Hilton described for me a brilliant fireball he had seen streak across the horizon. He told me excitedly how, while driving on a lonely road, he had seen the nocturnal landscape rendered as bright as day, and how the shadows of the sage brush rotated as the great light passed. Then he had cursed himself for not thinking to use the camera that hung from a neck strap.

"Well," I said, "you are an artist. Paint me a picture of that and I'll trade you meteorites for it." That picture hangs in our home. It also appears on the jacket of this book.

John did a lot of scouting about the desert and, recognizing a possible meteorite finder when I saw one, I coached John on what to look for and how to look. In the following years he sent me a report from time to time, but until 1948 none of his leads proved good. Then John wrote to me from Mexico that he had found a meteorite. He added that he had checked the maps and lists of meteorite finds carried in my book *Our Stone-Pelted Planet* and he was sure this was a new meteorite, since it was 200 miles from the nearest listed location.

When I wrote John to say how delighted I was at his news, I cautioned him not to be too sure it was indeed a new fall.

I had a hunch about his meteorite, and when I saw him I told him the story. Back in the 1890's when the Arispe meteorite first was found about forty miles south of Cananea, several sizable masses were brought out, and there was a tale among the old-timers that there was another big piece, one that had been kept for a time in a local shop, then loaded by its owner on a burro and taken away. They thought the meteorite had been taken to Magdalena. On my first hunt for Arispe irons in 1927 I had followed the burro and its burden as far as Magdalena, but had lost track there. This was half way to where John Hilton found his meteorite, and I had an idea his might be the donkey-borne Arispe specimen.

John and I cut off a little corner and polished and etched it—and there was the story. The structural markings of a meteorite are just like a signature, and this was Arispe, sure enough. John got more kick out of playing detective than he had out of finding the meteorite in the first place, and he promptly wrote another magazine story, this one about structural patterns of meteorites.

Hilton's meteorite had been used as an anvil for thirty-five years on a Mexican hacienda, mounted among the roots of an overturned stump. It weighs 269 pounds and bears a natural flat surface, eleven by five inches. The Arispe anvil piece is testimonial to the toughness of natural meteoritic steel; though pounded on for a generation, it shows no hammer marks. Several meteorites have served as anvils on farms. One of the Tucson irons was used by a professional blacksmith for this purpose for a number of years. Another homely need was filled by the Estacado stone, which was employed as a wash stand outside a kitchen door before it was sold for $1000.

No meteorite collector ever had better luck working near the Arizona crater than the late O. J. (Monte) Walters. Monte had a sharp eye and a persistent mind. Sometimes I thought he must in addition have a special instinctive perception of nearness of meteoritic material, for I never knew him to return from a collecting trip empty-handed.

In the early post-war days, surplus mine detectors were easily available, and I obtained a couple of these for use in locating buried irons. For me their performance was erratic.

We used an M 625 standard war surplus detector. This detector consists of an electric coil carried in a disk at the foot of a rod and connected with batteries borne in a pack. The electric current develops a magnetic field about the coil, and this field is affected by ordinary soil in such a way as to produce a faint steady hum in an earphone worn by the searcher. When a metallic object is passed over, the steady hum suddenly intensifies to a whistle or buzz, sometimes almost a bark. Unfortunately, the detector cannot distinguish the difference between a meteorite and a tin can, a piece of wire, a bottle cap, nail or any other object made of ferrous metal. The detector is sensitive to metallic meteorites of average size—about a half pound—to a depth of ten inches, and can indicate a two-pound iron buried as deeply as two feet.

Carrying and manipulating the machine requires some physical effort, but more than that its effectiveness depends in large part on aptitude of the operator. Monte Walters had a knack with these instruments. When he went out with a machine, the thing would hum busily, then go into a gleeful buzz that had Monte wielding his shovel at frequent intervals.

In 1946, the persons most familiar with the Arizona crater informed me that the land had been pretty well stripped of meteorites. One veteran hunter told me he personally had covered every foot of a zone three miles in width adjoining and encircling the crater pit with a metal detector. I did not doubt this Arizonan's integrity, but I judged him fallible. My experience with detectors, and my calculations years before of man hours necessary to cover such and such an area foot by foot, told me it would take about thirty-two years of steady searching, eight hours daily, to cover the area he described.

Monte Walters gave me no such picture of the "worked-out" nature of the crater vicinity.

"I can still find meteorites," he told me.

So I agreed to take off his hands at the then going price per pound all that he could find. I had taken on a tough obligation, because Monte proceeded to deliver. Sometimes it was difficult to keep our side of the agreement, and Monte would have to wait for his money, but he never complained and never doubted. During fifteen years he delivered to our museum approximately 4,000 pounds of meteorites, comprising some 12,000 specimens, for which we paid him a dollar to ten dollars a pound.

Walters had spent his early years as a cowhand in the neighborhood of the crater and had become familiar with the distribution of meteorites around the rim. Our agreement covered hunting on state land, and he searched on several sections on which we had filed mining claims, and on two or three others on which he had filed at my suggestion.

Walters was a fine friend and, in my scale of values, he was a great man. His devotion to his family, particularly his relationship to his sons, was admirable. Deer hunting, fishing and meteorite hunting were the weekend recreational activities for the boys and their Dad. During all of the many hours that I spent in their presence I never heard a cross word spoken. Monte always was firm and knew his own mind, but he also respected the minds of his sons, and their admiration and respect for him was almost worshipful. Monte died in a veterans' hospital July 8, 1961.

With a staff of two to four persons besides ourselves, I had time in 1947 to pursue the work at the crater under my permit. Despite the estimates that the great amount of collecting done during the past four or five decades had nearly stripped the environs of meteorites, we were anxious to make a thorough search.

A retired navy captain guided us to our most efficient metal detector. Captain Harold Draeger, M.D., had taken up meteorites as a hobby in his retirement. He came to our museum with a mine detector which he wished to try out at the crater. The first day he visited our museum I had a firm commitment that prevented my accompanying him, so Addie joined the captain and his wife on an excursion to the crater. I designated a location where I thought he might find something, and off they went.

When they returned that evening there was great excitement. The captain had located meteorites faster than the two women could dig them out from depths of a few inches; and when the catch was spread out on the floor of our living quarters we were indeed an excited group.

We at once purchased a detector like Captain Draeger's. Don Thompson was a good operator, and we kept it busy. He and I took turns and set out to give the ground a good going over with the expectation of being able to furnish a useful map of distribution of fragments.

3

For our first year on the desert we were busy and buoyed up by seeming success.

In the fall of 1947 I chased once more after the Danforth puzzle in the Maine woods, but returned feeling that perhaps it should simply be marked off my book for good.

During a long Sunday afternoon off, Addie and I drove to Long Valley and came back over the Mogollon Rim through a hundred miles of dense forest where occasional patches of aspen gleamed like candles in the dark.

We knew there were plans to change the course of Highway 66. Stories about the impending move of the old and dangerous narrow two-lane road, with its dips, decaying shoulders, and high incidence of traffic accidents, carried changing rumors as to the path the new highway would take. Finally it was settled that the new road indeed would bypass us, running a half mile away and to our rear, with only a dirt access road to our hill.

Still, the time for this happening seemed far ahead; besides, we were scouting possible sites for a new museum building, nor had we yet given up hope for an eventual institute and home on the crater rim.

Power company poles had begun marching over the desert in our direction, although they were not coming close very fast and we still depended on gas and kerosene light.

We hired a new, temporary employe. One of our visitors, Fred Boyer, showed so much interest in the place that when we found he was footloose we simply asked him, on a hunch, if he would stay for a while to help. Fred and Don put in some much-needed improvements. They hauled away rocks and dirt to make a driveway, set up parking barriers and built a garage of unique construction: a simple arrangement of old square-stemmed telegraph poles, purchased from Western Union, unloaded along the railroad and trucked in to us.

The visitors' count for November, 1947, surpassed 1,100. Our mail orders included a welcome $500 order for meteorites to be used in nuclear studies. Average daily attendance of sixty to ninety persons, with sales of literature and specimens, brought us, after sales and admission taxes, something over thirty dollars on an average day. Out of this we had to support ourselves and a staff, pay operating expenses, and retire heavy indebtedness.

Don and Ruth had begun preliminary work on an illustrated catalog of our collection, which was intended to be an historical account of its accumulation as well as a listing of its contents.

We began to dream that perhaps our museum would grow enough that it could support a research department manned mostly by college students and new graduates under one or two trained supervisors. Many of the researches, those involving chemistry for example, could be farmed out to other institutions.

Perhaps our glasses were rose-colored. We learned that the custodian at the crater rim had complained about our collecting, but we continued working in areas for which we had written permission. We began to notice that other parties were searching the same sector of the rim without filing the reports that previously had been made regularly to us for our records of any hunting done by visiting collectors and scientists. My map could have no meaning unless all finds by all parties were reported. Finally we abandoned the map, but continued to work the rim under our permit. The permit was renewed, for six months, ending in October of 1948. Addie and I filed for mineral rights on some of the intervening sections of state land within the cattle ranch. We staked claims and laboriously built up stone monuments to mark them.

By summer of 1948 the power line still had not reached us. The cost was going to be high. We installed a Wincharger—another mechanical device to watch after—and stored its rows of batteries in our telegraph-pole garage to p^»wer our own electricity. The Wincharger provided direct current, not alternating; Addie still couldn't use her electric iron and washing machine. The new highway snaked closer and closer to us and to the by-pass that would maroon our museum.

All of our efforts to have our program taken over by some respected institution had failed. When time seemed to be running out for us, we had come with great reluctance to the conclusion that either we must abandon our program and our dream or find a way to make our great collection support the program. When we decided that the environs of the great meteorite crater would be the best place to try, we had faced the fact that this probably would be our last move, that we would spend the rest of our days on the desert. What final disposition we would make of the collection was yet to be decided. When we had moved to Arizona, I had thought it probable that ultimately it would become the property of the Society for Research on Meteorites. It was my hope that such also would be the final custodianship of the great crater, although I had no intimation of this possibility from the owners.

My interests had been bound closely with those of the Society, and my association with its leadership had been close. I did not foresee that time would change this situation, nor that a space race eventually would transform the collection into a negotiable asset.

There were days when there was little traffic on the road below and less coming up our hill; there were days when heavy traffic passed on the highway—and passed right on.

Many cars continued to come up our hill only to swing away and go down again without a stop. Others brought the kind of troubles that persons who deal with tourists complain of everywhere: visitors interested only in restrooms, which often were abused badly; careless drivers who dislocated or smashed the parking barriers or who swept through our back yard with no care for our privacy.

And there were those occasions we so regretted when a visitor would pay, then obviously take no interest in our exhibits and our story. We had to follow some sort of established policy; if we didn't collect at the door, we couldn't collect even $10 in a day; but we hated having anyone leave feeling money had been misspent. Fortunately, those who took the time to look and listen seemed to go away pleased.

Ab Whelan, the geophysicist who had made magnetometer surveys in New Mexico oil fields for me, came to conduct instrumental researches for sizable meteorite fragments in the environs of the crater.

I had suggested to Ab long ago that with all his field work he undoubtedly had encountered a meteorite at one time or another without being aware of it.

Ab never had reported anything. But when he came to do the crater work he told me he had found a "big old rock" that he had thrown into his pickup truck and brought home to Artesia, but had just never gotten around to writing to me about it. He said he didn't suppose it was anything, but I told him to send me a sample when he got back to New Mexico. He did so. His "big old rock" was a meteorite that weighed 167 pounds. It had been resting in his yard for two years since he had found it lying out on a deserted ranch, near what had been the foundation of a house, not far from Acme, New Mexico. It was impossible to determine whether the metorite had been brought in, or lay where it fell, but searches failed to produce any further specimens.

We measured our days by changes in the weather and in the flow of traffic, and by the ritual totaling of the cash register tape each evening.

Winds blew so fiercely that our signs were toppled more than once, the garage roof had to be battened down and the trailer tied to keep it from blowing over, and heavy meteorites were shoved against the doors to hold them shut.

Electrical storms occasionally put our batteries out of order, leaving us just enough power for one small light at night. In winter our water pipes would freeze for a week at a time, thawing out on some evenings just enough for us to draw and store the next day's water supply. Snows would swirl about the building and drift the road up the hill so as to discourage visiting by all but four or six people, who perhaps stopped chiefly for brief refuge from the storm-driven highway.

On some days when slow traffic or bad weather brought a mere handful of visitors through our doors, better than usual sales of specimens and books would bring the total up to an average, or even record level; at other times only our mail order business made the difference by which we were able to survive.

During 1948 as compared to 1947, business all along Highway 66 seemed to be generally down, but for us, on the whole, it was better, perhaps because we had established ourselves as a going concern, or perhaps because 1948 brought us an unusually good press, with our museum featured in several major magazines and on newspaper pages throughout the United States and even abroad.

Because there was such a dip in business along the highway between the heavy traffic of summer and the slack of winter, we decided for the winter season of 1948 and 1949 that Addie and I would undertake a lecture-field trip while Don and Ruth cared for the museum.

We headed for California to fill lecture engagements and enjoy a little warm weather. We parked our trailer at Palmdale, California, one afternoon and next morning found ourselves surrounded by twelve inches of snow, with more coming down until there was an eighteen-inch blanket over the Mojave Desert. I rearranged lecture dates on foot and by telephone to accommodate the weather and it was three weeks before we could move our trailer.

However, we had a pretty good winter among high schools, colleges and rock clubs, the income from which combined with loans on two of my insurance policies enabled us to carry the museum deficit and pay off a $3,000 note. We spent five months in the Coachella Valley, the Mojave

Desert, the San Joaquin and Inyokern Valleys. Our points of contact were chiefly the mineral societies. In addition, we lectured to thousands of school children, many of whom lived on farms and ranches or on the desert and so had opportunity to observe and handle rocks.

We financed our travel by charging a small expense fee for lectures and by sales of meteorite specimens and books. The cooperating mineral societies received fifteen per cent of the proceeds for their own treasuries. Our overhead of car expense—pulling the trailer and going off on chases into rough country—was a burden on our margin of profit.

We returned to the museum the middle of March. Don and Ruth had struggled through a pretty tough winter, but we all looked forward now to the upswing in business and weather that spring should bring.

4

Early in 1949 came a press announcement that the University of New Mexico henceforth was granted "exclusive rights" to conduct meteorite surveys and to recover meteoritic materials at the Arizona crater. The announcement was made jointly by the University, the Tremaines, and the Barringers.

There were three separate contracts. The Barringers in theirs specified a prohibition against activities that might deface scenic beauty of the crater or damage permanently its scientific value.

The press announcement also mentioned that Dr. Otto Struve, president of the American Astronomical Society, had compared the Arizona crater with the site of a February, 1947, fall in Siberia, which he reported had been turned into a national monument by the Russians.

From this time on I confined my work to such of the checkerboard squares of state land sections in the environs of the crater as Addie and I already had constructed our stone monuments on or would continue to select for filing of mineral claims. At the time of the announcement I knew I was being criticized for "commercializing" the subject of meteorites by insisting that somehow I must collect a living wage from the thousands of persons who were visiting our educational exhibit, hearing our lectures, purchasing our literature and a few specimens. Our collection of more than 5,000 specimens representing 526 falls was made available every day in the year over a period of years for the inspection of any and all persons willing to pay twenty-five or fifty cents to make use of it. Reduced rates were available to groups.

My signal offense seemed to be that our museum sold specimens to collectors, to colleges, universities and museums. Also, on a much smaller scale, we sold jewelry made from the small nickel-iron meteorites we had retained from among those collected around the Arizona meteorite crater. In no case did we allocate for jewelry any specimen for which there could be any conceivable scientific need, nor did the jewelry constitute more than a very small item in our volume of sales.

A collection of meteorites properly labeled constitutes a more reliable source of information than any printed treatise on the subject. The shadings are slight between the relative grades of scientific respectability represented in receiving a price for a cabinet specimen for a scientific collection, and receiving royalties on a textbook.

Obviously, meteorites are too important scientifically and much too rare to justify their general use for ornaments or any other commercial use. So far in man's experience meteoritical material is several times more scarce than gold, and it is possible that a greater tonnage of diamonds has been recovered than the total of meteorites in all the museums of the world.

Because of their potential yield of information concerning the universe outside the earth, all meteorites should be strictly preserved for educational and scientific purposes except in those rare instances where the representative samples of a single fall exceed the demand by institutions of learning.

In the vicinity of the Arizona crater so many nickel-iron meteorites were recovered during the first three decades of the twentieth century that they became practically a dead item in the museum supply houses of the country. On the other hand, they were commonly offered to tourists in souvenir houses along the highways of northern Arizona as mere curios. No one ever will know how many thousands of these were sold between the time of discovery of the crater in 1891 and 1946, when we began, in cooperation with the crater owners, an effort to keep some kind of record of the number of such specimens recovered and disposed of.

During 1946 we developed ways to mount some of the small meteorites in the form of costume jewelry, sectioning and etching suitable specimens and polishing others along contour lines. The process was tedious and expensive, but it removed them from the "common rock" classification which they carried when sold in the rough as souvenirs, at perhaps a quarter each, most often to be tossed aside shortly and lost. A small meteorite turned from a nondescript "rock" into a $6.00 jewelry item surely would receive more care and attract more attention. Families of scientists in particular seemed attracted to our unique jewelry. We provided a proper label and descriptive certificate so that each piece carried with it a bit of knowledge that most certainly would be passed on to others.

The limited marketing of these small meteorites as jewelry and two other types of jewelry created from meteorite products—metallic spheroids encased and polished in plastic, and bits of jet-black polished oxide—may have made the general public more aware of meteorites than the combined efforts of institutional departments of astronomy and geology.

How "pure" is institutional science? How "commercial" must a private enterprise be? Every university employe, whether teacher or researcher, is paid a salary which is made possible for the most part either by taxpayers' monies or by the contributions and endowments received by private institutions. In spite of this support, these institutions charge enrollees some sort of tuition or fees.

Sometimes I would wish that the critic of my "commercialism" could be forced to spend a few weeks in my shop preparing paper weights, a pair of bookends, or a series of specimens for some enthusiastic collector. One simply cannot work with meteorites day after day without absorbing a lot of information. Preparatory work upon an extensive series of specimens constitutes a better textbook than has yet been written on meteorite structures.

If the order being filled is intended to serve as a study collection for students, or as a general reference collection, its chief function will be realized at its destination, where any number of individuals may be instructed by it. Nearly all of the contributions to meteoritical knowledge in America during the nineteenth century emanated from the pens of men who were associated with collections of meteorites. Could such collections have been developed without a great amount of preparation and direction? Can such preparational activities be undertaken without there being remuneration?

During the nineteen twenties and thirties I visited practically all of our leading museums and universities to inspect a sufficiently wide variety of specimens to meet my needs in respect to structure, classification and identification, and especially in relation to my favorite problem, the surface features of meteorites. One of the most impressive facts of these visits, emphasized repeatedly during my explorations was this: Practically all of the specimens in those collections, both great and small, had at some time passed through the hands of Dr. Harry Ward of Rochester, N.Y. or Dr. A. E. Foote, of Philadelphia, both of whom were out and out "dealers" in minerals and meteorites.

Our "commercialism" differed from that of these men in one important particular: Whereas they assigned research a minor and secondary role in their program, it was given first place in ours.

Since our operations were limited strictly to meteorites and were of necessity small, we seldom employed more than two persons. Several thousand specimens of several hundred falls were cut and polished in our laboratory. Each of those was inspected carefully under a hand lens, many were examined under high-power microscopes. We etched more than a thousand slices of nickel-iron meteorites. Many were re-polished and re-etched for purposes of research. All specimens were checked and rechecked by me personally. Important discoveries several times were made during the course of preparing a pair of bookends or a paper weight from one of the Canyon Diablo irons. A number of my scientific papers developed directly from observations made during just such preparation of commercial objects.

Exchange of specimens between museums and collectors is by dictionary definition a form of commerce, yet without this kind of activity knowledge of meteorites would have been more retarded than it has been. When one collection contains several stones of the same fall and another collection has a similar duplication from another fall, an exchange is to the obvious advantage of the scientists associated with both collections, as well as of the public visitors who view them. The practice of division and exchange has been followed by many of the men who have contributed most to our present knowledge of meteorites. Those collectors who have refused steadfastly to allow their meteorites to be cut and studied, or who refuse to make exchanges, seldom have added much to the world's fund of information.

My research plan would have foundered at its very beginning had I not been able to turn a part of its products into bread and butter, shelter, clothing and education for my family.

5

To all appearances the new road had been finished for some time by the end of June, 1949, but it was not yet opened for traffic. We had become accustomed to this situation; business was going along as usual. Then one day Don and I were both on duty. The day had been going pretty well. There came a lull and we were standing among the display cases discussing something or other when one of us remarked about the lag.

"This has turned out to be a dull day. I wonder why."

I walked over to the northwest window. The new highway bore a stream of traffic. The change had been anticipated, but when it came it was hard to believe. Our records for that summer showed that beginning on that day the income was just about cut in half.

There we were, landlocked in our desert, with the changed traffic patterns eating away at our success. We still were badly in debt. Now it was evident that we could not expect more than enough to pay the rent and the living expenses of two people.

The work was enough to be arduous for two, but attendance was not sufficient to carry four persons and expense. Reluctantly, with Don and Ruth, we faced the fact that we just couldn't justify, nor carry, the added expense of salaries for regular help. Don and Ruth returned to Denver, and our remaining time on Highway 66 was faced largely alone. We grew accustomed to caution about leaving the building alone even briefly, and Addie and I regularly traded the chores of going into town or staying on duty alone, and always arranged for someone to be at the museum when we were to be gone together even for an afternoon or evening. We found reliable and interested persons who would care for the museum on week ends or during more extended periods when we wished to be away for field trips or lecture tours.

There were two reasons why we refused to give up. One of these was a fact; the other was our old dream.

The fact was that we knew our collection represented great value and that if placed on the market gradually it would be sufficient for us to live on for the rest of our lives. We never had put any liens on the collection. Our experience had convinced us that it could not be sold in its entirety as a collection; nevertheless I knew its value and if worse came to worst we could give up our dream. For we still dreamed of a meteorite institute where such a collection as ours would supply information both to researchers and to the general public until this most interesting subject should find a place in high school and college curricula.

Those were lonely and sober days. Our entire lives had been committed to this program. The venture had proven itself effective and had been self-supporting. Nothing was being done anywhere in the world so far as we knew that in even a small way duplicated our effort, and we had expected to spend the remainder of our active years in this program. But now we were under such worries and pressure that we feared our health could not long stand up. I was having cold sweats at night. Bitterness had been growing, and fear—something I had hardly known before.

In the summer of 1950 there was great activity on the crater rim as a new building went up and huge signs advertising the crater blossomed all along Highway 66.

We still were thinking of constructing a new building that would front on the changed highway. We sought more and more to bolster our sliding admissions income by sales of meteorites. Ward's Natural Science Establishment, our first large customer so many years ago, again undertook sales on consignment to an extent that now was accounting for a third to a half of our income. We were selling off duplicate materials, and were beginning even to offer for sale specimens that heretofore we never would have dreamed of letting go. At the same time we began to make efforts to find a purchaser for all of our Nininger Collection, or for substantial divisions of the whole.

Margaret returned to Arizona in the fall of 1949 and spent nearly a year with us, assisting in final preparation of *The Nininger Collection,* the catalog of our meteorites, published in 1950. By the time the *Catalog* reached print we were despairing of our survival as an institution. We made up our minds that if a buyer for the collection did not appear shortly following publication of the *Catalog,* we would have to split the collection into several sections to be sold separately, or close shop and dispose of it piecemeal. Two things saved the museum from being closed. The first was our inability to find a buyer for the collection. The second, the unexpected but controlling factor, was that we found we could not set ourselves free of our lease.

When we had not found a buyer by summer of 1950, we decided we simply must quit; that at the end of the season we would store our collection and close the museum, sell enough meteorites to build ourselves a home and somehow work out a new life.

Our lease had been expensive to purchase, and we had been careful to include a clause allowing either party to cancel on sixty-days notice; but somehow the clause was left out of the final draft and Addie and I failed to note its absence.

We sent our sixty-days notice only to be countered with a statement that we would be bound by an automatic renewal provision, paying our monthly rental whether we occupied the building or not, until July 1, 1953.

As in previous crises we tightened our belts. We did some close figuring, changed our program here and there, cashed in one insurance policy and borrowed on the others and made do.

Although, looking ahead into them, those next three years seemed endless, in reality they were in some ways less difficult than the years preceding, except for the continuing tensions that prevented our feeling free to come and go at will without a constant presence at the museum.

Because business was lighter, the work was less, despite the fact we were carrying it alone for the most part. By bringing in temporary help, we were able to attend a number of important scientific meetings that were welcome breaks in routine. Arrangements could be made easily when the events were close at hand; when they occurred at great distance, I would manage to line up lectures nearby in time and place to allay expenses, and would carry specimens to sell or, where possible, follow up a report in the area that might bring in a new specimen.

Frequently our museum was visited by scientists of national and international repute who wished to examine our collection. Usually I would accompany such guests on a visit to the crater to explain my most recent researches.

I was beginning to have a whale of a time with these crater studies. Day and night I worked with soil samples gathered at the crater, sifting and sorting for hours at a time, with each operation adding a little more to the solution I was formulating for the puzzle of what exactly had happened out there on the desert eons ago. It seemed that I would never get through my work at the crater; never had I been so busy in all my life.

The excitement and stimulation counteracted the tensions and problems of our life. Growing scientific notice of what I was doing, and resulting attention in the press, were reflected in the attitudes of townspeople and seemed even to influence somewhat the flow of visitors to the museum.

*No one regards what is before his feet; we all gaze at the stars.*

—*Iphigenia.* Quoted by Cicero in *De Divinatione.*

# 11. DISCOVERY

Years before, when Dr. F. R. Moulton visited Denver in 1936 he and I lunched together at one of the local hotels. Our talk turned to my book *Our Stone-Pelted Planet,* published three years earlier.

"I see that you hold to the view that there is a big meteorite in the bottom of the Arizona crater," Dr. Moulton remarked.

I replied that D. M. Barringer had decided so and that according to his records such a mass had been encountered by drill.

Placing his hands on the edge of the table, Moulton leaned toward me with a smile.

"Nininger, there cannot be a meteorite in that crater."

"Why not?"

He explained that he had investigated this whole matter mathematically and had concluded that it was impossible for a mass of any such magnitude as that which produced the crater to stop suddenly and remain intact. On impact it would have to be transformed into gas; it would explode.

I admitted that Dr. Moulton had a much better right to an opinion than I, but said I still believed the mass must be in the crater.

Moulton had been employed in 1929 by Mr. Barringer's organization to give them a valid estimate of the tonnage of metal that they might expect to recover in a proposed mining operation. The professional scientists in the Barringer group had considered Moulton to be the man best fitted to make such an estimate, which was to serve as a basis for seeking the necessary financial backing for the project. These men had been thinking on the order of ten to twenty million tons of metal. When Dr. Moulton theorized a mass of only three million tons at the most, perhaps as little as fifty thousand tons, that could have survived the impact, the financial sponsors panicked and withdrew their support.

Dr. Moulton did not tell me all of this background, which I learned later. He only told me his conclusion.

"There cannot be a meteorite in that crater. It is mathematically impossible."

As the years passed I tended to agree more and more that Moulton might be right. Being a field and laboratory man, however, I felt I simply must have more than figures to satisfy me on a problem which involved matter colliding with matter. The Arizona event had taken place recently enough that a very raw scar still marked the site. The answer as to the fate of the impacting meteorite must still be available if a sufficient search were made.

I said to Dr. Moulton, "If you will secure some funds for me I'll go to Arizona and prove your theory, if it is correct; or, if you are wrong, I think I can prove that too." He was noncommittal.

Later, I wrote to Dr. Harlow Shapley of Harvard to the effect that I believed the vast amount of exploration at the Arizona crater had been centered mistakenly within the crater itself, and that if the correct answer to that puzzling feature ever were to be found, it would depend on exploration around the crater rather than in it. If Moulton's theory were right, then certainly the proof of it must be found, if at all, on the outside.

In 1939, through the good offices of Harlow Shapley, I received $250 from the American Philosophical Society, conditional on my securing a matching amount, to conduct a search for small fragments at the Arizona crater. Dean Gillespie provided the matching amount, and I designed and had constructed a magnetic rake to be drawn as a trailer behind our Studebaker car.

With my son Bob and Irving Hoglin I drove down to the crater and we combed some twenty-three acres of the more barren terrain within the two-and-one-half-mile zone surrounding the pit. Our harvest was some 12,000 small nickel-iron fragments—total weight, forty-two and one half pounds. A pattern of a radial distribution was indicated.

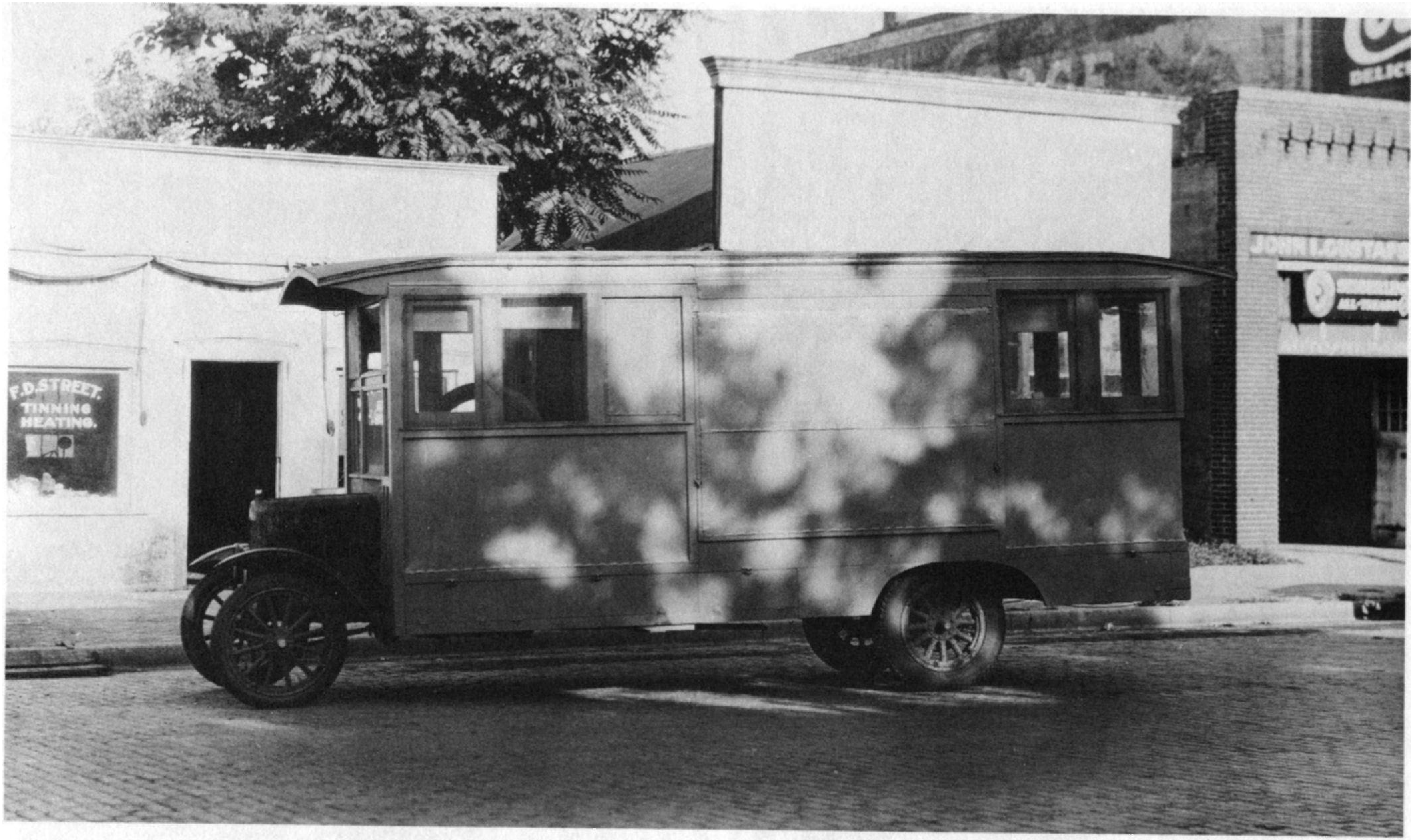
During the next decade I carried out various other researches in the vicinity. Cattlemen who held grazing leases on state land as well as private holdings objected to further use of the magnetic rake. Magnetometer search, too, was stopped short of completion by objection of property owners.

During the frequent meteorite-hunting excursions that Addie, Margaret and I made in the summer of 1946, my interest turned more to the dust and small particles of sand grain-size that continually collected on our magnets. Back at the trailer below Mt. Elden I spent many hours going over these small particles which en masse always gave a strong chemical reaction for nickel. Much of it I could recognize as small chips of oxide and an even larger portion seemed to be volcanic ash.

I suspected during that summer that I was finding the condensation products which Merrill had declared were lacking and which the Moulton explosion-theory seemed to require for its verification, but our trailer

*Goose Lake Meteorite ready for loading*

*Goose Lake, California, Meteorite,*




*Nininger Runabout 1925–26.*

facilities were not adequate for the complete examination which the several types of material that we were collecting required. Such study would have to await our move and the opening of our museum, the time for which had been set for September.

When finally we got our collection moved into the old rock building on Highway 66, there were months of installation problems even after we opened, and to our gratification we found our time very much occupied with caring for visitors. The research on crater materials still must wait. When museum attendance reached the stage where we could employ help, then all my spare time was devoted to research problems.

During the life of our permit to search we collected nearly 6,000 specimens from the outer slopes of the northeast sector of the crater rim. Only a few of these weighed as much as ten pounds. The two largest weighed fifteen and seventeen pounds. The average weight was about four ounces.

In the course of collecting these small specimens we took numbers of soil samples by means of a hand magnet mounted at the tip of a cane. These magnetic soil samples were sealed in envelopes, marked by location and set aside for study when time would permit.

After October, 1948, when withdrawal of my permissions for research made it impossible to continue exhaustive and definitive collecting, I concentrated my efforts on the alternate sections of public lands on which we obtained rights, and also began to take out of storage the bags and boxes of soil samples collected as far back as 1939 and laid away pending time for analysis of their content.

In the sorting of fragments gathered during the magnetic rake survey of 1939 we had discarded all material that would pass an eight-mesh screen. As we sifted out and cast away this great bulk of fine particles, I had begun to wonder whether perhaps we were culling the most important part of our harvest, and so I had bagged up a goodly sample of the discard for laboratory study and carried it back to Denver, but I had not got around to examining it.

The greatest keys to my evolving theory about the crater were found in my boxes of soil samples. I was beginning to be certain that neither I nor anyone else had given to the soil in the environs of the crater the careful attention deserved, and when I turned my attention to the small particles of various descriptions that crowded the soil, the most exciting avenues of exploration and speculation were opened.

When a sample of magnetics from the crater area is examined under a lens, the view is of a confusing variety of particles of many shapes, colors and description. Some shine, some are dull. Spherical particles are not uncommon, nor are ovals, biscuit shapes, pear shapes, perfect droplets.

We had found that the hand magnet would pick up from ant hills richer loads of the little pellets of rounded or oval shape; perhaps the ants tended to favor the rounded or oval heavy grains in building their hills, but more probably the wind blew away the lighter volcanic ash and left behind a disproportionate amount of the heavier metallic grains.

Barringer and B. C. Tilghman in 1905 had reported finding an abundance of small black magnetic particles in their work at the crater. Tilghman described these as "blackish-gray" in color and of "torn, irregular" shape; he stated this material was "absolutely universal over the whole locality inside the hole and out for as far as observed, somewhat over two miles from the hole."

The material constantly adhering to our magnets agreed with this description for the most part, but as I pored over the stuff, picking out particles one at a time, I found some that did not conform. These were rounded, gray or brown in color; they responded positively to nickel tests, and when I attempted to grind them in a mortar, I found they had malleable metallic cores.

By early 1948 I had concluded that here was one of the condensation products necessary to Moulton's explosion theory. In 1949,1 reported to the American Philosophical Society the results of oxidation studies I had made under a society grant: I described these metal-center pellets and also the finding of oxide droplets, rich in nickel and black in color, but without the metal centers. Continuing studies revealed other condensation particles—reticulated pellets consisting of soil and sand particles bound together by a reticulum of nickel-iron oxides, and globules of silica glass coated with oxides.

When we first began studying these magnetics in the soil samples from the crater area, the little metal-center pellets, with their coverings of sand and soil, were the most apparent. It seemed that these must have been formed by condensation from metallic vapors in the absence of oxygen and arrived on earth as raw metal, then bound to sand and soil grains by the cementing action of oxides. But if they indeed had been formed in the absence of oxygen, the process must have taken place in the heart of a large cloud of metallic vapors or other gases from the core of which oxygen was excluded. What, then, had happened to the large enveloping portion of the cloud? There must be other particles present in the soil.

The metal-center pellets made up but a small part of the magnetics gathered. They were easily separated out, being one to two millimeters in size, but even without them our samples consistently showed the presence of nickel. Isolating another kind of nickel-bearing particle was a real puzzle. Attempts to separate and test groups of similar-appearing particles failed, and finally it seemed the only answer was to test individual particles for nickel.

At least a hundred particles must have been tested, individually, before finally, when one more particle was dissolved and subjected to the dimethylglyoxime test, a beautiful strawberry red appeared in the test tube.

Surprisingly, the nickel-bearing particle was neither round nor black, as I had expected; it was brown and had a somewhat lumpy surface, though it tended toward the spherical in shape.

Once we had learned how to recognize these and separate them from the several other kinds of magnetic particles, we took hundreds of samples on all sides of the crater and found that these metallic droplets were present in the top soil to an extent that projected to thousands of tons! Here, then, was the proof of Dr. Moulton's explosion theory. I could think of no other way to account for these little droplets, two and a half times as rich in nickel as similar sized irregular fragments, than that they were condensation droplets from a meteoritic cloud produced by the explosion which Moulton had hypothesized. I named these droplets *metallic spheroids.*

Further testing and chemical analysis by F. G. Hawley showed the metallic cores were extraordinarily rich in the percentage of nickel—17.30—and these particles, even as small as .1 mm. to .2 mm. in diameter, bore only a thin coating of oxide; it was evident that the idea that all small particles resulting from the disintegration of large meteorites would undergo immediate oxidation was seriously in error.

The survival of these tiny bits of pure metal was exciting. The spheroids, so tiny that 280,000 of them would weigh an ounce, were found as far from the crater as five miles. At that distance they were distributed at a rate of a few hundred pounds to the square mile; close to the crater rim the concentration was on the order of a thousand tons per square mile. We measured the quantity of spheroids in sixty different locations on state lands and estimated that from 4,000 to 8,000 tons must be present in the upper four inches of soil within an average radius of two and one-half miles from the crater rim. By projection, taking into account the processes of weathering, it is not unreasonable to estimate that the original deposit totaled as much as 100,000 to 200,000 tons.

I worked a very long time at the problem of separating the little metallic spheroids from among magnetic particles of volcanic ash, magnetic sand, oxide scale and several other substances. Since we had no shining laboratories with complicated technological apparatus at our outpost on 66,1 was working with the most rudimentary of equipment. Some of our visiting scientists took amusement in my primitive ways, and some of them carried back to their universities and industrial plants raw materials that I gave them, wishing to test or demonstrate ideas or technics of their own, but none of their methods proved to be practical.

Meanwhile, with no complicated gadgets at hand and with no mechanical skill worth mentioning, I continued experimenting until I could make a perfect separation on a small scale using nothing more complicated than a few small aluminum baking pans (actually, toy cake pans), a magnet, a series of sieves and some cardboard boxes such as I could pick up at a dry goods store.

My simple set of procedures was tedious, but it worked, and that is something that none of the highly technical laboratory and university scientists were able to claim for their schemes. One noted scientist laughed heartily as he watched me slide my pans and boxes back and forth over a magnet, making capital of the fact that the particles were both magnetic and rounded and thus could be sorted out by their responses to the forces of magnetism and gravity and the principle of the inclined plane, but when my visitor tried his own method the result was failure.

Spurred on by discovery of the little metallic spheroids, I searched and searched everywhere on all sides of the crater, on the rim and on the plain beyond, examining everything more critically than ever before, and one day made an even more exciting find.

I had stopped to examine a gravel pit dug into the crater rim by the state highway commission. I found a few crushed bits of yellow-green-brown slag; some showed a gray outer crust. I looked for more, and soon picked up a small tear-shaped piece. It appeared the same color as the light gray dust and gravel among which it lay, but the rockhound's licking test revealed a dark greenish-gray color under the dust. A canteenful of water dashed onto the gravel made it easier to identify a number of such small "bombs" of various shapes and sizes. All of these, when broken, were seen to be of a spongy structure, but composed of brittle, glassy material. When I ground the bits of slag on a sheet of carborundum cloth from my supplies in the trunk of my car, and then held them under a pocket lens, they showed small imbedded metallic particles, bright as chrome steel.

As I drove hurriedly back to the museum on Highway 66 to make a nickel test, I puzzled over various questions. Could these be mere volcanic cinders? Could lava fragments carry such imbedded metallic particles? If these indeed were bomblets created by the impact of the meteorite, why had they never before been discovered?

Then I remembered that on the far side of the crater rim, the side nearest to the closest volcanic mountain of the area, lay scattered numbers of volcanic "clinkers" that were similar to, though larger than, the bits of volcanic ash familiar on all sides of the crater. Every scientific and other visitor to the crater had walked over these heedlessly. Some scientists had picked them up, casually examined them and tossed them away, pronouncing them volcanic lapilli. It seemed not illogical that the cinders nearest the source would be larger than those on areas farther from the volcanic mountain.

I, like everyone else, had trod over these "lava bombs" with complete disinterest, but now I was ready to look at them with somewhat more respect. The nickel tests I ran that evening on my little bomblets were positive; the next morning I drove to the crater to study the clinkers on the southeastern rim.

Mingled with the rubble of the crater rim were tiny droplets of melted country rock, some as round as bird shot, others pear-shaped, oval, cylindrical with rounded ends, and still others of almost any imaginable shape and ranging from microscopic to the size of walnuts! One could kneel in a single spot and pick up 200 pieces without even moving. Some looked just like those from the gravel pit, but others seemed to be mere volcanic cinders. All, when ground on my carborundum cloth, showed metallic grains. Here again was the question of possibility of metallic grains within the volcanic ash.

I began walking toward the volcanic mountain seven miles away, stopping frequently to search, keeping a keen lookout all the time. The bomblets thinned rapidly beyond the first 1,500 feet from the crater, and hardly any were found farther than a mile from the rim crest. I walked more than halfway to the mountains, and as I went the fine-grained volcanic ash became more and more abundant and slightly coarser, but nothing was found to match my glassy-metallic slag of the gravel pit and crater rim.

At the Henbury meteorite craters in Australia, and at Wabar in Arabia, explosion products had been found, little glass bombs, shot full of tiny, nickel-iron spherules, to which had been given the name *impactite* in reference to their origin: glass bomblets formed by a melting of rock by the meteorite explosion, and scattered through a mist of nickel-iron.

The riddle had been asked often about the Arizona crater: Why were there no glass bombs like those at the Australian and Arabian craters? It always was assumed in these discussions that the Barringer group would have found impactite had it been present. The mathematical theorists always had an answer based on proper mathematical formulae, and those of us who were not mathematicians listened. I don't recall ever hearing anyone suggest that it might be well to make a search. The situation reminds me of the classical illustration of medieval logic—the argument over the number of teeth of a horse, a dispute that waxed so hot as to end almost in violence and that was left unsettled because no one thought to look in a horse's mouth.

Scientists had speculated and estimated in their attempts to explain the crater, but never had done much looking. Now we had an answer: There were such glass bombs all the time. Arizona had its impactite, but we all had been walking over it so carelessly we did not see.

Perhaps there is a lesson to be learned from this story of Dr. Moulton, the Arizona crater and its owners, and me: that team work between theorists and scientific fact-gatherers is a necessary part of good research.

Moulton should have insisted on a more thorough job of fact-gathering before accepting the assignment to furnish the Barringer organization an estimate of mass within the crater. And he should have visited the crater.

On the part of the Barringer group, the failings were the very inadequate fact-finding survey of the crater and its environs, and the later and less-excusable failure to view with open mind the work done by others, which left for the public a confused picture of what happened some 20,000 to 50,000 years ago on the southwestern American desert in what now is Arizona.

Looking back on our luncheon of 1936 from the perspective of many years, I wondered if my failure to grasp Moulton's point of view may have been the reason that his proposed efforts on my behalf came to nought, if perhaps he decided quietly, then and there, that I was not capable of usefully employing an endowment for research. If this were true, he gave no indication of it and, in fact, continued visible efforts for several years beyond the occasion.

My work more and more convinced me that Moulton's explosion theory was correct and that the great meteorite that dug the Arizona crater had vaporized on impact. My report to the American Philosophical Society in 1949 pointed in this direction, and in October, 1950, I made public announcement to the press of this belief.

Many scientists have wondered if large meteorite impacts may be accompanied by atomic fission. Calculations by British scientists led to the conclusion that such impacts should produce temperatures comparable to those developed in the explosion of atomic bombs. It is well known that the surface of the soil was left glazed by the heat of the first atomic blast in New Mexico in 1945. In December of 1953 I was permitted to visit the atomic testing ground at Yucca Flats, Nevada. Not only was the surface of the terrain under those blasts glazed, but several thousand tons of surface rock had been melted and reduced to vesicular blobs of slag and glass, scattered by the fury of the blast to great distances. All of the various shapes and sizes of impactite bombs found at the Arizona meteorite crater were duplicated at Yucca Flats to the most minute detail of structure and form, except that those of Yucca Flats contained no nickel-iron particles.

No longer is the Arizona crater the largest known meteorite crater: A recently recognized Canadian crater gapes seven miles wide, and there are others also that are larger, but none boasts the fortunate combination of size, accessibility and freshness of the Arizona pit.

It is recognized now that there undoubtedly are many major and unexplained topographical and geological features whose origin was the impact of giant meteorites, comets or asteroids, and that other such features have been obliterated by ages of geologic change and erosion past recognition. The great "canyons" of the ocean floors may well be of impact origin; fossil lava flows may be the result of ooze from the plastic interior of our earth which spread from wounds gouged out by invading bodies from space.

When we moved near the crater in 1946, our friends voiced skepticism. Hadn't all angles of this fifty-year-old discovery been investigated? Certainly nothing remained to be discovered where a million dollars had been poured into exploration.

I believed that all of the most important facts had been observed and recorded, though I suspected there might be some need to reclassify and restudy certain accepted theories. I was amazed to discover that there were basic inadequacies in the manner of attack on the crater problem, or problems.

*First,* each of the writings on composition and structure of the meteorites had been based upon the study of one or a very few specimens. It seems obvious that no safe generalization could be made relative to the nature of 100,000 individual specimens simply by study of a few.

*Second,* no thought seemed to have been given to the possibility that specimens taken in different locations relative to the crater might show different and significant characteristics.

*Third,* nearly all of the monies expended—in today's dollars probably an amount equivalent to a million and a half to two million—had been devoted to exploring the crater pit on the assumption that the principal bulk of the colliding mass resided in its depths, despite the conclusion by many scientists that such a huge mass would of necessity explode on impact. If the colliding mass had exploded, the logical place to look for the evidence would be not the bottom of the pit, where it was necessary to work under several hundred feet of rubble, quicksand and water, but rather on the terrain surrounding the crater.

There was no indication that any careful study had been made of the soil of the surrounding plain nor of the outer rim slope. Our subsequent investigations demonstrated that an expenditure of a few thousand dollars on that terrain would have supplied facts more in harmony with the best scientific theory than did the extensive and expensive efforts inside the pit.

The prime purpose to which our collecting efforts were directed, and which would have been served by the comprehensive mapping originally intended, was to prove or disprove a pattern for the distribution of fragments about the crater.

It is unfortunate that it never was possible to complete some of the projects started. However, the specimens collected, their characteristics and the information I had as to their sources made possible some studies and conclusions.

Despite the interruption of the mapping activity, I knew the quarter section from which any one of half of all the fragments we collected had come. I knew still more specifically the locations of 5,000 specimens, and the depth of the layer of soil from which any of them had been dug. From the cowboys and other collectors of earlier days I had learned the approximate locations where hundreds more of the larger specimens had been collected.

Our 1939 survey had suggested strongly the radial distribution of small fragments around the crater. I made it a point to ask the cowboys and other meteorite hunters if there seemed to be any pattern of distribution. Their answers revealed that these men regarded as guides to good hunting areas lines drawn from the center of the crater through any locations where finds had been made. This evidence of radial distribution was offset by distortions of the pattern, notably a concentration of small irons on the northeastern rim of the crater.

Altogether, I spent more than 25,000 daylight hours within sight of the great crater in Arizona, and put in more than 2,000 hours of work in and around it.

I had scouted the crater's interior and exterior and had studied it from the air. An excellent set of aerial photographs was made available by the photography school of Lowry Air Force Base at Denver. A study of prevailing wind patterns and examination of the crater out-throw as shown on these photographs supported an explanation that the heavy concentration of fragments on the northeastern rim was due to wind.

Approximately 500 of the meteorites collected by us had been cut into sections, either by me personally or under my personal supervision. I had etched and studied some 1,500 sections under magnification.

In 1936 I had discovered among several etched specimens from around the crater one that evidenced by its structure and composition an origin different from the rest. This I named Canyon Diablo No. 2. Then, as we sectioned and studied more and more of the crater irons we soon learned that not all of these specimens had come from the same meteorite, for their "signatures" did not conform to a single pattern. As more and more were cut we discovered not only additional representatives of No. 2, but at least four more types—evidence that either a swarm or a small system of discrete bodies had traveled together, rather than just one large mass.

When the question was raised as to whether the crater was formed by one mass or a great swarm of meteorites, all of the attempts to answer were based on mathematical investigations as to the mechanical possibilities and probabilities. No one seemed to think of hunting for material evidence to support either hypothesis.

All of the small meteorites taken on the crater rim showed evidence of having been altered by heat, while fragments of similar size taken from the plains beyond the crater rim showed no such evidence.

My examinations of etched specimens under microscope revealed thousands of inclusions, including forty groups of the famous *carbonados, or* black diamonds, found not infrequently in Canyon Diablo specimens and occasionally in other meteorites. I made an attentive study of the carbonados and of the incidence and relative abundance of inclusions of cohenite and schreibersite, troilite and kamacite.

Fitting together various findings, I developed a theory as to the formation of the crater. The evidence of a composite fall, the distortions of a radial pattern of distribution, the evidence of heat alteration in small fragments found on the rim and not elsewhere; the distribution and nature of the so-called shale balls, found mostly on the crater rim itself, and the finding of explosion products—metallic spheroids and impactite—seemed to me to indicate the impact of a planet-satellite group of meteorites, which on first striking the earth produced a shattering of the outer zone of the mass wherever it contained brittle inclusions, while the body of the meteorite bored inward into the earth to a final greater explosion of the violence of a hydrogen bomb. Remnants not vaporized shot downward and deep into the fractured rock or upward as red-hot and white-hot slugs—the rim specimens that showed heat alteration.

The most significant conclusion was this: The Arizona crater is a great part of our national heritage and should have been so treated from the first; since it was not, certainly now it should be acquired and given to the public as part of the national parks system.

The Antiquities Act of 1906 has met with the approval of practically every citizen in a near unanimity of opinion not often given congressional legislation. Only the Antiquities Act prevented the complete destruction of the now world-famous Petrified Forest when, in 1906, plans were being perfected by commercial organizations for the crushing of the beautiful agatized logs for use in the making of sand paper, grinding wheels and other abrasives. Such scientific marvels as the great Natural Bridges, Zion Canyon, Muir Woods, Rainbow Bridge, Craters of the Moon, and early vestiges of civilization like Montezuma Castle and Mesa Verde would have suffered mutilation or destruction but for the protective hand of the National Park Service.

It has become a part of the American way of life to set aside those outstanding bits of creation so endowed by nature as to contribute importantly to man's understanding of his environment. Thus our national government protects the heritage of all her citizens of present and unborn generations. But because man gains knowledge of his environment mostly by short steps, each new advance paving way for the next, certain features unrelated to their immediate surroundings and without counterpart in man's previous experience have gone unrecognized for generations.

Such was the situation with the Arizona crater. Regarded by scientists for a half century as of questionable import, this feature of the Arizona landscape now looms preeminent as a potential storehouse of vital information. The world's finest example of meteorite craters, regarded by some as easily the most significant scientific marvel of the American continent, passed into private ownership by virtue of mistaken identity and compounded error.

The crater was interpreted in 1891 as of volcanic origin, rather than formed by meteorite impact, by G. K. Gilbert of the United States Geological Survey. Dr. Gilbert was a very learned man of his day. He had considered the idea of impact, but he took the more conservative stand and pronounced the pit a volcanic blowout, which it resembled in many ways. After A. E. Foote, Gilbert probably was the first man to suspect the existence of meteorite craters, but no one could know very well what the appearance of such craters might be. In any event, his mistaken determination of volcanic origin set the stage for the next blunder.

When a mining engineer learned twelve years later of the crater and of the persisting story that it had been formed by a meteorite, he conducted some explorations and then promptly filed a mining claim on the land. The United States Department of the Interior committed the second error when it accepted the Barringer estimate that the crater contained minable ore and granted title as mining claims. Although law required proof of the existence of ore in minable quantities before application for title, the crater ownership through half a century has failed to yield a single ton of such ore.

But now the presence of a large body of meteorite has been shown to be an impossibility. Instead of being buried in the pit, the meteorite material is disseminated in the soil around the crater and in the fill within. This conclusion is reinforced by all other investigations of meteorite craters in other parts of the world: Meteorites large enough to produce craters above a few hundred feet in diameter simply do not reside in the craters they produce but are reduced to gases and dust, blowing themselves to bits out of the craters they have dug.

The now-accepted explosion theory that debunks the claims for mining wealth within the crater is in itself an overriding reason for preservation of the crater as a national treasure. The study of explosion products and the effects of the explosion on surrounding rocks looms as an extremely important area of investigation. We do not know, for instance, the extent of alterations produced in the materials of the earth's crust by the brief application of tremendous pressures beyond compare in other phases of the earth's behavior.

Within the last few years two completely new minerals have been produced by application of high pressure to common minerals of the earth's crust, and a subsequent search proved that both of these minerals are present in the Arizona crater. It seems regrettable to allow this tremendously challenging laboratory to lie unused any longer. Extensive explorations should be made in the surrounding rocks to ascertain just what changes, and how far-reaching, were created by the impact.

Accessible as it is and of such large size, this crater should be studied thoroughly in every aspect, and serve as a standard by which to evaluate other discovered craters less well preserved and either larger or smaller than the Arizona "type" specimen.

The expensive explorations carried out by mining interests since passage of the Arizona crater into private hands in 1903 had the avowed purpose of exploitation and resulted in some degree of mutilation of some of the most meaningful parts of this magnificent product of cosmic collision. To serve its greatest usefulness it should have been kept under strictest supervision by a skilled staff of scientists, every square foot of the great pit and its surrounding uplifted rim, as well as the out-thrown rubble and the surrounding plains, being made accessible to all interested citizens without danger to preservation.

When the 1947 meteorite shower in Siberia resulted in formation of some third-rate craters (in point of size), Russian scientists attacked the problem with a corps of specialists including astronomers, geologists, meteoriticists, metallurgists, geographers, photographers, artists and surveyors. Buildings were constructed over some of the Russian craters to preserve them in undisturbed condition for future generations.

The United States has fallen far behind the Soviet Union in this sort of study. Russia has had a National Committee on Meteorites for nearly forty years. This committee has attacked the problem of meteorite craters in a manner of thoroughness which far surpasses anything done in the United States.

The craters produced by the fall of 1947 in the Sikhote-Alin mountains of southeastern Siberia were not large and therefore did not yield all the different types of information which could be gleaned by study of larger craters, but they did produce some rather striking results and without question have lent impetus to the ballistics program of the U.S.S.R.

Canadian government surveys indicate that old meteorite scars of large size on the earth may be innumerable. Canadian scientists have found at least twenty almost certainly proven craters larger than the one in Arizona. One of these, about seven miles in diameter, is a conspicuous feature, and others up to thirty miles in diameter have been proven by core drilling to be of impact origin.

Our own great nation had the first introduction to this very important question of impact scars and still has the finest example, yet is far back in the procession of study of this aspect of the earth's relation to the solar system. As a National Monument—a recognized part of our heritage, receiving deserved scientific attentions and attracting the awed respect of traveling Americans—the crater would bring honor to the owning family and constitute the greatest possible tribute to the late Daniel Moreau Barringer, who in the face of frustrating opposition continued to work in support of an unwelcomed and controversial interpretation of the crater as of cosmic origin.

*fe hath no leisure who uses it not.*
*—George Herbert, Jacula Prudent urn*

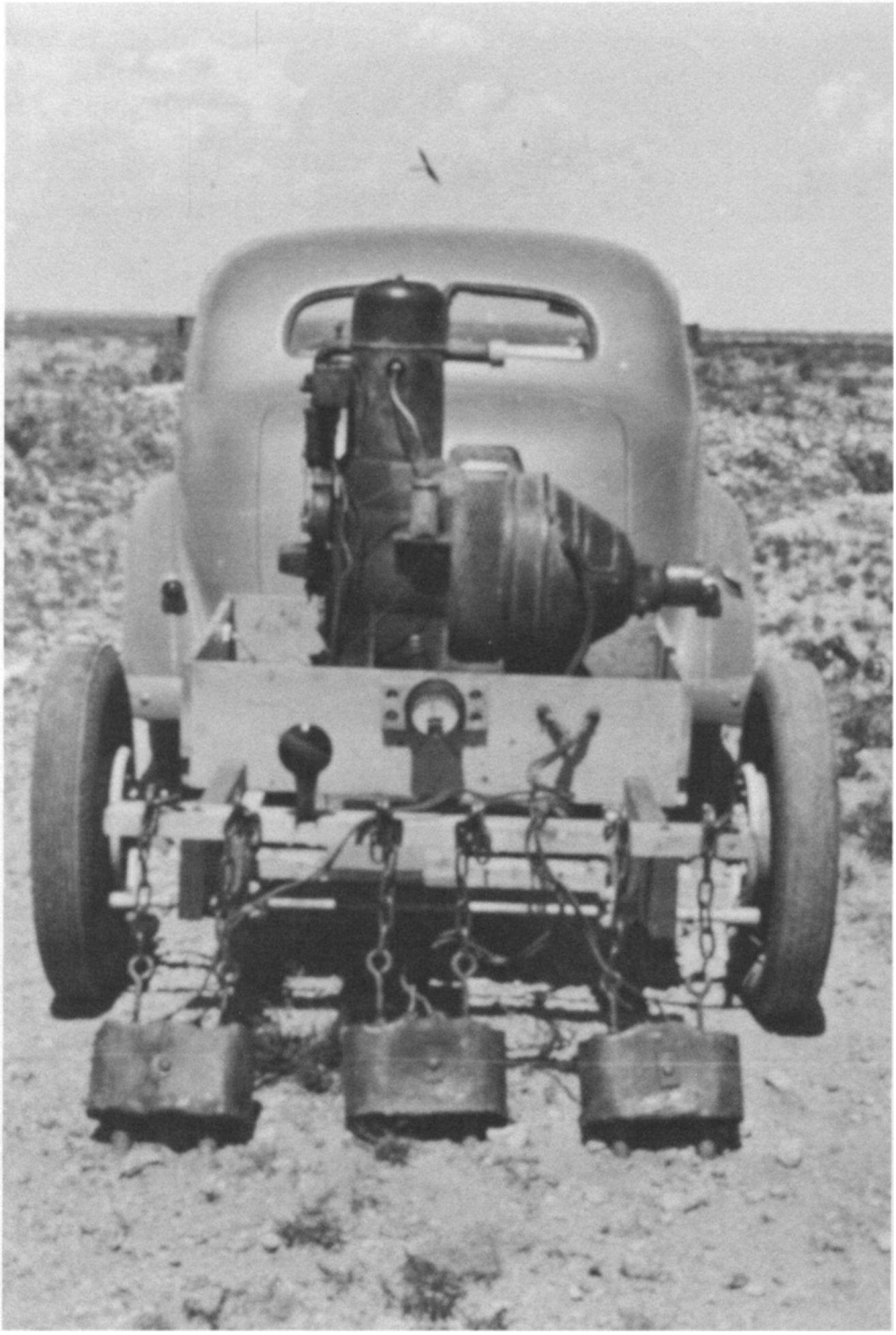
# 12. HOME

There were tense moments, hours, and days as we looked from our hill and saw the traffic speeding on the new highway with seldom a vehicle approaching by our narrow dirt road. But when we had recovered from the shock we turned to the tasks at hand. One of our chief objectives in coming to this place had been to give us an opportunity to carry on crater investigations. We now set about re-ordering priorities. We sold some oil leases which I had picked up during my war job with the solar Oil Company. We upped our offerings of sales material (meteorites) and I devoted much time to crater investigations. During those forced three years I made some of my most important discoveries.

During the last two months of our forced stay on the hill we scouted and found a location in, Sedona, Arizona, just south of Flagstaff, about thirty miles to the southwest; and new friends lent us money for the construction of a suitable building. While they supervised its construction we took care of the summer tourist trade up on Highway 66.

In September, 1953, we transported our tons of meteorites down the steep, twisting Oak Creek road to our new building. It lacked the picturesqueness of the old "observatory," but was fresh and clean and bright, and the downstairs apartment seemed to us the ultimate in civilized comfort after our seven years of mud walls and one-room housekeeping. We had nurtured the few green growing things—cactus and Chinese elm—on our wind-torn hillside; now we had space for grass, for flowers and vegetables, with plenty of precious water to support them. We had ordinary, dependable alternating current electricity; Addie was reintroduced to the ease of housekeeping equipment with plugged-in power. After seven years, we were again part of a community, with neighbors, shops and convenience.

Our business started out well enough to encourage us that the Sedona move would prove to have been wise, but we were not so busy, nor were the burdens so heavy, as on Highway 66 even after the move of the road.



*Magnetic rake designed by Dr. Nininger*


*Dr. Nininger collecting magnetics on Crater rim. From these he separates the spheroids which are believed to be condensation products from the exploded meteorite.*

It seemed more of a thrill than when my own first book was published to receive in 1954 a copy of *Minerals for Atomic Energy,* written by our son Bob, then deputy assistant director for exploration of the division of raw materials of the Atomic Energy Commission.

In 1955 Margaret and her husband, Glenn Huss, came to Arizona to assist us. As well as sharing the load of conducting visitors through the museum, they helped us with a new book, *Arizona's Meteorite Crater,* and a revision of *A Comet Strikes the Earth.*

When he was a boy Glenn Huss lived in Horace, near Tribune, western Kansas when I was lecturing in that part of Kansas and at times I had Alex Richards lecturing in schools in that area also. On April 17, 1937, Glenn wrote me concerning what he thought was a meteorite that he and another boy had found.

At the time Glenn Huss was no more important to us than a hundred other boys who got our message; but about 1950 he went to work for the University of Denver Press and there he met Margaret who was also working there. Glenn had a master's degree in English and the two were married two years later. Glenn was much interested in meteorites ever since hearing the school lecture 15 years earlier.

In 1954 when we needed help in the Museum in Sedona we offered him a job and he took to the work as a duck takes to water. He's an avid reader, has a marvelous memory and he had a natural liking for chemistry and all kinds of science.

In *Arizona's Meteorite Crater* I retraced the feature's past history, outlined my conclusions as to its formation, and reiterated my hope that the crater one day would belong to the nation. I suggested twenty-eight specific researches to be undertaken to evaluate the great event of ages past in relation to scientific undertakings of the future.

In 1953 Dr. Loring Coes, Jr., while subjecting quartz to intense heat and exceedingly high pressures, discovered that he had produced a new mineral harder and more dense than quartz by 13.5 per cent. This was named *coesite.* I was putting the finishing touches on my manuscript for *Arizona's Meteorite Crater* when I read the announcement of Dr. Coes' discovery. I read also comments by eminent geologists to the effect that coesite could never be found in nature; that it could not be produced short of sixty to 100 miles below the surface of the earth because only at such depths could sufficient pressures exist.

These men were overlooking a point. Many physicists had calculated that a meteorite striking the earth at even a minimum speed of five miles per second would exert a pressure far greater than that produced in Coes' laboratory. Consequently, I appended a suggestion which appears as a footnote on p. 50 of the *Crater* book and recommended again on p. 154 that a search for this mineral should be made in and under the rim of that crater. It was with a feeling of great satisfaction that I read in *Science,* July

22, 1960, of the discovery of coesite in shocked sandstone from the Arizona crater. The discovery of coesite triggered further investigations into the changes wrought on the rocks of the earth by the exceedingly high pressures exerted by crater-forming meteorites, and some of these investigations turned up another new mineral, *stishovite.*

In *Crater* I suggested that the diamonds found frequently in Canyon Diablo meteorites may have been formed at the instant of impact instead of arriving from space in the meteorite. During some twenty years of handling and cutting irons from the crater I had noticed that all of the diamonds encountered were in "rim" specimens, those found on and near the crater rim, all of which showed effects of high temperatures, and so I raised the question whether the diamonds might be the result of high pressures and temperatures. I theorized that these rim specimens came out of the very final explosive fragmentation that had taken place in the depths of the pit, where most of the meteorite was reduced to gases and dust and the remnant in the form of small pieces had been shot high into the air and then had fallen in close.

Dr. Michael Lipschutz and Dr. Edward Anders of the Fermi Institute, whose meticulous researches proved the hypothesis, credited me for the origin of the idea and the loan of diamond-bearing specimens to explore it.

I was just completing *Arizona's Meteorite Crater* when late in 1952 I discovered the presence of impactite on and in the crater rim. My manuscript preparation was interrupted by some two years of investigations into the nature, distribution and quantity of this fascinating material.

2

On October 10, 1957, when Sputnik was about one week old and still dominated our nation's news pages, a huge, brilliant fireball flashed across the morning sky of three western states. A highly trained pilot, a lieutenant commander of the navy, reported that he had dodged the fireball and then watched it disintegrate beneath him when he was flying at 17,000 feet.

My survey of this meteor showed that the point of disintegration was at a height of several miles over the central Colorado mountains, more than 150 miles from the plane. In a Sputnik-oriented world this pilot's error was a serious blunder. For if the observations of highly trained pilots and military men were no more accurate, it would be as easy to confuse a meteoritic fireball with an intercontinental ballistics missle. But the navy pilot had made his report: "I was flying at 17,000 feet near My ton, Utah, when I saw this flaming object coming from my left in what I deemed to be a collision course. Quickly, I banked and turned. As I did so the great fireball disintegrated under me in a shower of sparks. I resumed my course and when I looked back saw that several small fires had been started."

Far to the north in Wyoming, men on night duty in an oil field reported that a blazing object as large as one of their huge field tanks passed over, narrowly missing some of the storage tanks. At Grand Junction, Colorado, far to the southwest, observers trembled as they saw this dazzling light glide to a landing on the slope of Grand Mesa in western Colorado. From Alamosa, 200 miles south of Denver and slightly west, it was seen to disappear behind the railroad watering tank. At the same moment men in the control tower at Lowry Air Force Base in Denver, looking west, saw the object disappear over the eastern part of that city.

A Denver resident, one of the few abroad that morning at 4:07 when the meteor swept in from the northeast and disintegrated over the central part of Colorado, described his reactions to me.

"I was standing right here. Had just come out to get in my truck; you see, I haul trash for people and I get out early. I had just opened the door of the truck to get in and there she come! I'm telling you it was the scariest thing I ever seen, twice as big as the sun and ten times as bright! Sputterin', throwin' off sparks and big hunks of white-hot stuff. I was scared to death. Tried to call my wife. She was right there in the kitchen, but I couldn't talk. I stood here trembling and pointing. It was all over in a few seconds. Passed right over that telephone post and only about ten feet above it.

"Listen, they say it was a meter or something like that. I know better. I seen it. I know. That was Sputnik. And I knew that he could turn a death ray on me and just evaporate me. I want to tell you, I never been so scared in my whole life."

The office of the North American Air Defense Command at Colorado Springs reviewed all of these conflicting reports. Charged as it was with the nation's protection against intercontinental ballistics missiles as well as all other forms of sneak attack, this office could not allow itself to be misled by the conflicting, fear-inspired reports of a lot of frightened laymen. The military concentrated on the report of the navy pilot. A commission was dispatched to Vernal, Utah, the region where the officer had made his observation.

The commission began its investigation by flying over the area where the object was supposed to have disintegrated under the navy plane. No evidence of any fires was found. Nor was any debris seen that could be considered the remains of the fiery object that had frightened citizens of three states.

The commission then inquired of citizens in the little city of Vernal. Yes, one testified to seeing the object disappear about seven or eight miles southeast of the town. Out went the officers, but they seemed to approach no nearer to their goal, for residents here pointed still farther to the southeast.

"Right on the north slope of that mesa. I saw it strike and there was a great shower of sparks when it hit."

The officers went to the mesa slope, but found nothing. They queried residents of the vicinity. Again they were told that the object had struck farther to the southeast. Was this a hoax, hallucination? Whatever these people had experienced must be an entirely different phenomenon from what the navy officer had reported.

Back in Vernal, more witnesses were questioned.

"Go see Bill Higgins. Bill is a down-to-earth level-headed rancher who is honest as the day is long."

Yes, Bill Higgins told the investigating officers, he had seen the strange fireball. It landed within a quarter mile of his house; but it was not southeast of town by any manner of means. It was southwest about fifteen miles.

"It struck right behind a little hill just back of my corrals. Looked like it would blow up the whole earth; but I never heard a sound."

Close further questioning convinced the commission they now had been pointed to the right spot.

But there must have been more than one object, Bill added, for a friend of his out north of town said he saw one hit not far from his house at about the same time.

The more the commission investigated, the greater grew the confusion. After searching a few locations they returned to headquarters and filed their report as an unsolved mystery.

Had these men gone with Bill Higgins to his ranch and asked him to point out for them the spot where he had seen the object strike, he would have pointed toward the southeast; and his friend north of town would have pointed in the same direction. The men in Alamosa would have pointed north and a little west. Those in Grand Junction saw the fireball a little north of east. Witnesses in Estes Park saw it pass on the west of them, going south, while the men in the oil field in Wyoming saw it in the direction of their oil tanks south of them, seemingly so near that they feared it would hit them and start a disastrous fire. Actually, the meteor was forty miles high, but to them it appeared no higher than it had to the trash hauler in Denver.

The great fireball was of such magnitude that if it had passed within a half mile of a man he probably would not have lived to report it. But it never came lower than about twelve to fifteen miles above the earth. Most of the witnesses, including the navy pilot, had seen the object more than 150 miles from them. Only in the vicinity of Eagle, Colorado, had people seen it from less than forty miles. At about twelve to fifteen miles altitude, some ten to fifteen miles south of that village, the mass disintegrated. Those who were awake within a twenty-mile radius of Eagle heard a tremendous blast, followed by a thunderous roar and rumble, and a few in that sparsely settled region, who had been awakened by the glare and blast, reported they actually heard stones thudding down among the dense covering of scrub.

Investigation depends on such simple tools as protractor, ruler, pencil, map and a listening ear. I never definitely concluded that any of the many fireballs I surveyed failed to deposit meteorites, even though meteorites were found in only a fifth of the surveys made. When a fireball vanishes at a height of five to fifteen miles, which is the rule with those that produce meteorites, it is impossible to designate a target for the surviving fragments smaller than eight or ten square miles before any recoveries have been made. To search such an area for objects the size of a walnut or a brickbat is like searching a haystack for the needle. Additional problems are rugged or highly vegetated country and the possibility the fallen fragments are the size of peas or grape seeds or only sand-size particles.

3

One of the century's great scientists, truly the father of space flight, was Robert Hutchings Goddard. I have a very clear mental picture of Dr. Goddard on the occasion of a visit to his laboratory near Roswell, New Mexico, late in 1930, when he had just started his liquid propellant rocket research. The professor showed a very modest attitude toward his work, as there leaned in a corner a somewhat battered length of what appeared to be aluminum tubing, nearly double the height of a man, resembling somewhat an over-sized stove pipe. Professor Goddard explained this cigar-shaped rocket had just been recovered from a flight that reached a height of seven miles—the first verified successful flight of his new experiments in propulsion, guidance and recovery of rockets. Goddard's patented gyro was the heart of the rudimentary rocket, guided by two sets of vanes and with a parachute contained in the nose cone to ease return. His stove pipe was the forerunner of all the great space-probing giants of today.

Asked just what was his objective in these tests which the press had been playing up as his "futile" efforts to reach the moon, he said very modestly that his hope was to explore the upper atmosphere. I was sure in my own mind that Goddard's ultimate aim was to help make space exploration possible. That modest scientist who blazed the trail for space exploration throughout the world was financed so niggardly that one wonders how he accomplished anything at all.

Goddard began his experiments with solid proplellant rockets during the last of World War I, when with funds from the Smithsonian he developed his first single-charge rocket in 1918 at the Aberdeen proving grounds. With the end of the war the project was shelved, but it fathered the bazooka of the Second World War. Dr. Goddard then had joined Clark University in Worcester, Massachusetts, and alternated service there for some years with his experiments in New Mexico, which were suspended on a couple of occasions for lack of funds. In 1939, by which time he had succeeded in sending a sixteen-foot rocket aloft eight or nine thousand feet, he tried to interest the Army Air Corps, but the only future the military saw for Goddard's rockets was the development of jet-assisted take-off. So Goddard aided his country in two wars, but he was too far ahead of his time for his real hopes to begin to be realized before his death.

Rocketry was not related to my line of study, but as I studied the flight patterns of meteorites, which encountered the same forces and impediments as rockets, and as I examined and studied the surface markings of thousands of meteorites, I came to conclude that when and if projectiles were developed with speeds approaching those of meteorites, blunt or rounded noses would have to be provided instead of the sharp, pointed front ends being promoted in the first years of rocket and missile research.

While on a lecture tour in the east in the mid-thirties, I went to see the Yale collection of meteorites. Records showed that a large number of the small pellets that had accompanied the fall of larger stony-iron fragments near Estherville, Iowa, in 1879, were preserved in the Yale museum, and I asked to see these. Dr. William E. Ford, in charge of the department of mineralogy and of the meteorite collection, was most helpful. For two or three days I was allowed to study as I wished. In this time I examined more than 600 of the little pellets.

Various scientists before my time had described the Estherville fall, one of the great falls of history, but the significance of the rain of small particles was an aspect that seemed to have been overlooked. Dr. Ford told me I was the first person to show any interest in Yale's Estherville pellets in the fifty years they had lain in the museum. These small irons had been set free as irregular lumps of metal in the disintegration of the large mass of stone and metal. A veritable hail storm of little nickel-iron nodules was described by a small boy who at the moment of the fall was driving the family herd of milch cows toward home past a small shallow lake. He said the surface of the lake "was peppered like in a hail storm," and that "the cattle had stampeded in all directions." It was learned later that the little metallic pellets had rained down over an area some six or seven miles in length. Several thousand were picked up by the curious who took time to hunt for them. The pellets varied in size but averaged about the size of filbert nuts.

I had studied the structure of the main mass of Estherville through specimens on display at various museums. This meteorite has a sort of fruitcake structure consisting of a matrix of very brittle stone in which are imbedded metallic nuggets of various sizes down to microscopic grains. The rain of pellets had resulted from the crushing of a large mass by atmospheric resistance, thus setting free the little nodules. A great "smoke cloud"—dust, of course—had been reported at a height of some fourteen miles.

Apart from this unique shower, very few metallic meteorites had ever been recovered promptly enough after arrival for a detailed study of surface features as they existed at the end of flight. Oxidation soon begins to modify this aspect of a body that has not been exposed previously to the active ingredients of the earth's atmosphere.

About thirty per cent of the pellets I examined showed signs of "orientation"; they had fallen without whirling motion and with sufficient force and speed to produce frictional shaping—a melting away and molding of the forward part while the protected rear portion remained relatively unaffected.

It was this group of small oriented specimens that intrigued me most. Their flight markings showed they had traveled in a stabilized position without tumbling action; their noses were almost perfect hemispheres. Similar rounded noses had been among the stones gathered from the Pasamonte fall. They did not conform to the ideas then set forth by writers on meteorites as to shapes to be expected in stones fallen from space.

This discrepancy led me to devote a good deal of time over several years, beginning in 1934 or 1935, to search among the other groups of meteorite specimens for that small percentage which showed this characteristic orientation, and to examine carefully the remaining evidences of violent and fiery passage through the earth's atmosphere.

Among the 600 Estherville pellets at Yale's Peabody Museum, the shape of one tiny, blunt but streamlined specimen caught my special attention. This significant little meteorite later was given to me by Dr. Ford.

The idea of the *blunt nose* for missiles was born that day in the museum at Yale but was obliged to wait for more than twenty years. Through two decades the experts called for appropriations for the construction of greater and more powerful wind tunnels for use in discovering the most stable and least resistant designs for shaping the missile nose, yet all the while tested models from the greatest wind tunnel of all were lying unused in the meteorite collections of the world. Every meteorite that tunnels its way through the atmosphere to land on or in the soil brings with it a record of its struggle against a current more powerful than can be supplied by the most modern wind tunnel. These tested models stare up at visitors from museum cases and although they have penetrated the equivalent of several yards of rock, sometimes it seems their messages are unable to penetrate the gray matter of the engineers who look at them.

In 1935 and 1936 I published three papers describing the surface features of the Lafayette, Bruno and Pasamonte meteorites,* in each case discussing the effects in terms of flight markings of their atmospheric travails.

***"The Lafayette Meteorite,"** *Popular Astronomy,* **Vol. XLIII, No. 7, Aug.-Sept., 1935; "The Bruno Meteorite,"** *American Journal of Science,* **Vol. XXXI; "The Pasamonte, New Mexico, Meteorite,"** *Popular Astronomy,* **Vol. XLIV, No. 6, June-July, 1936, pp. 6-7.**

The Lafayette specimen is one of the best examples of the results of an oriented flight through the atmosphere; the position of the stone in flight is quite evident. The spheroidal front is abundantly and evenly beset by a host of fine crinkly ridges of blackish glass radiating from its central point. Describing it in 1935, I wrote:

> Altogether the lined surface of the stone gives one the impression that it has been formed by the cooling down from a condition in which the surface of the entire front was in a liquid state to a temperature below the melting point of the stone which allowed the molten matter to congeal while in the process of being swept away . . . the almost flat base . . . appears to have been developed in a situation where almost no atmospheric disturbance existed. . . . Here, in the wake of the moving mass was apparently an almost perfect vacuum. . . . We may think of this rear side of the meteorite as a furnace, for over its edges came the violently heated blast of air which closed in to fill the constantly forming vacuum which was always advancing rapidly enough to elude the inrushing air. ... a very effective furnace . . . which differed from the front exposure of the meteorite mainly in being in a state of calm, or rather, being in a vacuum.

Examination of thousands of completely encrusted individual meteorites convinced me that there is a critical velocity beyond which aerial friction operates differently from its effect at lower velocities.

> In meteorites traveling at several miles per second we encounter a condition which differs notably from that which obtains at lower velocities. The drop-shape with a rounded front and a tapering rear, which is considered the least resistant form in mechanical devices, is seldom attained in meteorites, probably for the reason that the velocity is too great. Consequently the destructive erosion which would be expected on the lateral and leeward slopes is not in evidence. In fact, the drop-shape is notably absent in meteorites. In the few instances where found, such as the Boogaldi and Charlotte irons, we find the evidence of aerial conflict limited to the *rounded large end which was the forward end in flight probably because of its form rather than that the form resulted from this position.*

The oriented Estherville and Pasamonte stones did not conform to the idea that a falling meteorite must be cone-shaped then prevalent among aeronautical and ballistics engineers and among writers on meteorites. In 1934 I heard a presentation by an aeronautical engineer which suggested as applied to automobiles, a pointed tail and blunt front. The only consistent feature I found among oriented meteorites was a dome-shaped or hemispherical front end; the remainder of the meteorite might be almost any shape.

The most perfect example of oriented flight markings on a meteorite of some size is the Bruno, Saskatchewan, Canada, meteorite (twenty-eight pounds). Its graphic flight markings indicate a rocking motion of the meteorite during a portion of its flight and, again, a rounded nose at the front with a low pyramidal base which at no time received the force of the air blast.

Surface features of individual specimens had been dealt with in the various descriptive papers of those meteorites; but so far as I knew no writer had undertaken to survey a large number for the purpose of group study. I examined a total of nearly 7,000 meteorites, including 800 metallic or partly metallic specimens, in eighteen institutions and two private collections in addition to my own, and including two institutions in Mexico and one in Canada. My studies of surface features were reported to the second and third annual meetings of the young Society for Research in Meteorites in 1934 and 1935.*

The 1935 paper "Surface Features of Meteorites" dealt particularly with surface melt and erosion during flight through the atmosphere. The 1936 paper "Further Studies on the Surface Features of Meteorites" treated orientation, form and pitting of meteorites. In the 1935 presentation to the Society I stated:

> Without question here is a field which should prove a fruitful source of information on questions of aerodynamics and ballistics. The engineers who are concerned with the problem of stratospheric transportation would doubtless find much to interest them in the study of meteorites which have survived a flight through the upper regions of the atmosphere . . .

In a progress report on our program published in *The Scientific Monthly* of August, 1938,1 predicted that "Aeronautical engineers will learn much from the study of meteorites before they master the stratosphere."

In the prospectus for a meteoritical institute submitted to the Penrose Foundation in 1940 was a section predicting "Practical Benefits" of such an institution. In listing a dozen such advantages I included as Numbers 8 and 9 the following paragraphs:

> 8) Thorough investigation of the explosive disintegration which marks the finish of the luminous flights of meteorites, coupled with a detailed study of the heat effects registered in the fragments col-

•"Surface Features of Meteorites," *Popular Astronomy,* Vol. XLIII, No. 2, February, 1935, pp. 121-126. "Further Studies on the Surface Features of Meteorites," *American Journal of Science,* Vol. XXXII, July, 1936.

lected from these falls and consideration of the forms which characterize surviving fragments, should throw new light on the problem of air resistance to high velocities. Here is an opportunity for aeronautical engineering to gain new light on problems connected with stratospheric transportation. Problems which face stratospheric flying are difficult to solve chiefly for the reason that they lie beyond the reach of experimentation. Meteorites are constantly meeting with those conditions as they land on the planet. By a careful study of them together with the light phenomena which mark their arrival a better understanding may be had of the difficulties which flying craft will sometime have to meet.

9) The science of ballistics will need more and more to study the forms and markings of meteorites as the velocities attempted by ballistics engineers approach those of the invaders from space.*

My findings in the areas of orientation and surface features were reported in detail and generously illustrated in *Out of the Sky* in 1952 and additional photographs of oriented specimens were included in the catalog *The Nininger Collection of Meteorites* in 1950.

Perhaps I have been as much interested in the space program as many of those actively engaged in it; all meteoritical studies are directly or indirectly related to space. Apparently my papers on oriented meteorites and the nature of their flight were not read, at least not at the time of publication, by persons prepared to give practical effect to the information contained in them.

As experimentation with missiles reached the point where engineers were attempting supersonic velocities it seemed clear to me that they could well copy the contours of oriented meteorites—that is, in place of the needle nose which seemed to be their ultimate objective, they should adopt the dome-shaped, or blunt nose, which I had concluded must be developed by an meteorite that achieved stablized flight through a considerable portion of its atmospheric transit; in other words, one that had maintained an oriented flight.

As we entered World War II and our government was calling for ideas from the public which might expedite our military preparations, I took up the matter with Dr. Forest Ray Moulton, whom I knew to be one of the chief advisers on ballistics, and who, of course, had worked on meteorite problems as well as in the fields of astronomy and mathematics. But I found that Dr. Moulton disagreed. We argued at length, but he remained unconvinced.

In July, 1942, I sent to the National Defense Research Committee of

***During the 1960's experiments by Dr. Dean Chapman, using modern wind tunnels, clearly demonstrated the formation of spheroidal fronts on glass and other substances.**

the Office of Scientific Research and Development a memorandum outlining facts about meteorites which I believed to have an important bearing on ballistics. I described, briefly, the matter of orientation:

> These meteorites have been irregular in form at the time they were set free from the parent mass. Yet strangely enough, each of those which maintains an oriented flight acquires on its forward end or side a form which is closely similar in at least ninety per cent of the cases. This form closely approximates a hemisphere and is not cone-shaped as much of the literature on meteorites would lead one to believe. My statements are based upon my personal scrutiny of nearly eight thousand specimens of fresh meteorites which had been collected before terrestrial weathering had modified them.

I further stated my belief that when a body moves through a gas at such a sufficiently high speed that its surface is constantly melting, then it behaves like a body moving through a liquid and acquires the form of least resistance for a solid passing through liquids, and I recommended that a projectile might be provided with an alloy jacket of low melting point.

In response to a request from the Ballistic Research Laboratories at Aberdeen Proving Ground in 1948,1 listed my papers on surface features and offered to make available for study at the museum, my examples of oriented meteorites, adding that I was glad the writer shared my conclusion that ballistics engineers would find it profitable to study oriented meteorites.

The cover of *Science News Letter,* July 26, 1952, depicted a needle-nosed model missile streaking through the Ames Aeronautical Laboratory wind tunnel at Moffett Field, California. The accompanying article stated that such was to be the shape of new, faster-than-sound superplanes, yet to be built. Man, the article added, probably never would fly at such speeds, except for momentary tests, because of speeds, heats and altitudes the human body could not stand. Heating was listed as the newest formidable barrier.

Under date of August, 1952, I sent to the Ames Laboratory a letter suggesting comparison of the pictured needle nose with the "blunt nose of my little Estherville meteorite which was shaped by aerial friction," of which I enclosed a photograph. I recommended that a foil of the same shape be subjected in the wind tunnel to the same velocity mentioned in the *Science News Letter* story. The reply I received, written by an "information specialist," was that wind tunnel experiments would not be feasible and that he had discussed the matter with several staff scientists, who believed "that the rounded shape of the meteorite's nose is due as much to thermodynamic action as to aerodynamic forces."

I wrote again, to the effect that "the thermodynamic factor was directly and wholly dependent upon the aerodynamic force" and that "I still feel that these little pellets record some facts that will prove vital to progress in your line of research."

I did not pretend to be able to decipher the message that I was so sure meteorites carried for the space effort and the drive to develop long-range missiles. What I sought to convey was that there *was* a message, and I suggested again and again and again that it was in the national interest to find out what that message was.

On June 1, 1957, the cover of *Science News Letter* carried a drawing of a new "nose for missiles"—the blunt nose. The shape conformed almost exactly to that of my little Estherville meteorite. The accompanying article announced that the blunt shape "helps to beat the problem of excessive heat that is generated when the hypersonic missile re-enters the atmosphere" and revealed that the Distinguished Service Medal of the National Advisory Committee for Aeronautics had been awarded to H.Julian Allen for the discovery.

Allen had reached his conclusion mathematically; it was also stated that the blunt nose had been adopted for offering more resistance rather than less. In a personal encounter some years later, Allen cordially convinced me he had reached his conclusion independently.

The evidence I had seen written on the blunt faces of meteorites, ridged and flowed over with molten flow lines, led also to my submitting a suggestion that a low-melt jacket be placed on all high-speed missiles.

There was a period in the development of space craft when it seemed an apparent impasse had been reached because engineers saw little, if any, hope that a craft could be designed that would not burn up during its return passage through the atmosphere or at least develop a lethal temperature for any human occupant. Over a considerable period our museum was visited by numerous representatives of the space program who were looking for information regarding some metal that could be relied upon to resist the heat of friction. These men reasoned that if the meteorite had survived its passage through the atmosphere it therefore possessed a peculiar type or degree of resistance to heat.

Two engineers from one of the principal government research centers in the East launched into a discussion of the re-entry problem, explaining why they thought that I, having spent many years studying meteorites, might know what substance or substances in meteorites were responsible for their great heat resistant qualities. As I told them that they had been entertaining a completely false conception, that meteorites possess no such quality, I could not be sure whether their faces were merely registering let-down or contempt for my ignorance. I explained that meteorites survive to reach the soil simply because there is sufficient material on entering from space that some is left over when deceleration is accomplished. Then I told them that the Bruno specimen beside which they were standing did have an important message, that meteorites in reacting to frictional heat develop a form which should be used as a guide to engineers in the shaping of nose cones. I proceeded to a discussion of the blunt nose as against the needle nose then in use on all missiles and rockets, and showed a number of examples, among them the little Estherville irons.

After several such encounters I concluded there are certain mathematically-minded individuals who can only read mathematical formulae—that natural objects make little impression upon them unless accompanied by a graph or a formula. I, on the other hand, am perfectly blind to their brand of mathematical interpretation. In short, I can read meteorites; they can read formulae. We do not speak a common language.

Perhaps my awkward, nonmathematical presentation did find its mark in some of the many discussions which were carried on in our little museum. I could never trace such an influence, but it would be my hope that some of my lectures and conversations stimulated some young fellows to thinking along lines that led them to work in the space program.

Certainly meteorites carry the message of the blunt nose plainly enough, having written the formula on their own noses in flight; and certainly the examples in my museum, clearly labeled and described, were examined by many aeronautical engineers, missile and rocket men during the years 1946-57.

4

During one of the off-times at Sedona when I was busy with research problems and not on duty in the exhibit room, I was interrupted to greet a visitor from Jordan. It was Dr. Dashani, director of antiquities of that country, who was visiting the United States under auspices of the state department. He seemed greatly intrigued by the meteorites and began asking questions as to why we were operating the museum, how and where we had acquired the collection. I told him that we were just about ready to bring the museum operation to a close.

"Why? Why do you have to do that? You say you are not able to make it pay. Why doesn't your government give money for it? It gives money to our country to finance various cultural activities. Surely your government would finance your museum?"

It was rather difficult to discuss this matter with a stranger from another country which received aid funds from our own, but actually he was speaking thoughts I held in my own mind from time to time.

I went through again in my mind all the reasons I had so often laid out as to why the museum should not be sold:

Activities associated with its operation and the field program which preceded it had been responsible for recovering at least half of all the meteorites discovered in America since 1923.

The collection had furnished a major share of the meteoritic materials used by many institutions in recent researches concerned with the space age.

Here had been presented to the general public more information about meteorites, in an easily understood manner, than was offered by any other American institution, and here, too, had been a source of information for specialists—geologists, astronomers, aeronautical and astronautical engineers.

The exhibit materials constituted an ideal "textbook" to prepare teachers for the presentation of a basic course in meteorites which could correct the current unfortunate and total lack of elementary instruction in this important subject.

In the exhibit cases and in our storage boxes were ample materials for investigations currently being carried out and for researches that should be undertaken. In the files lay data which for lack of funds remained uninvestigated and which might well yield returns in meteorites recovered at least as great as had been achieved through all our previous field work.

There were, in these post-Sputnik years, advanced researches into various aspects of meteorites going on in many laboratories. Some of these new studies require the destruction, or partial destruction of meteorite specimens, and thus the present limited supply is being used up rapidly. Nothing, so far as I could tell, was being done to replenish that supply other than the program we had started so many years before.

There was no adequate integration of various researches, no coordination of them with the elemental field facts which make meteorites such an important link in the chain of understanding of the earth and its parent solar system.

I sharpened a pencil and once again outlined the staff and budgetary needs for a properly functioning meteoritical institute. I figured that an endowment of two and one-half million dollars would be needed to support a staff of a dozen, modestly-salaried, ranging from janitor and secretaries to the director at a recommended $12,000 stipend, plus an additional $300,000 for building and equipment. The annual budget for the proposed institute of 1939 had been less than half the $97,000 figure I estimated now. Money had not been forthcoming for a plan that would have put the Nininger collection "at the disposal of the Institute for exhibition and research purposes."

It would have been a great boon to see my museum program continued. The first years at Sedona had held promise, but by the fall of 1957 it had become evident that the winter months never were going to become fruitful enough to support more than minimum expenses of the museum, nor could the summer provide carry-over for the offseason. Addie and I spent the winter of 1957-58 in California again with our trailer, supporting ourselves by sales, lectures and field work without drain on the small income from the museum, where Margaret and Glenn remained on duty.

Once more we were faced with the old questions: Whether and how to keep the museum; whether and how to dispose of the collection. To depend substantially on field work and lectures was too strenuous for me at past sixty.

When we had found ourselves stranded for three more years at our old location away from the new highway, I had written to a number of leading scientists of known interest in meteorites, disclosing that our situation would require us either to divide the collection or sell it entire.

They had answered, "No, don't sell the collection unless you can sell it whole." The response uniformly signified that the welfare of science best would be served by keeping the collection intact, if possible, and by placing it, if possible, with a university where it could serve research as well as display.

But we had not been able to sell the collection whole, or even bit by bit, so we ventured to borrow heavily again and built our new exhibition building in Sedona on the assumption this beautiful little town would become a mecca for nature-minded tourists. The move was good; the town boomed; but the boom was in terms of retired couples and art-oriented people, mostly. It was apparent that we were at a stalemate. We had assumed that as the town grew, and awareness of our museum's location grew, business would increase, but it stayed about the same.

My friend Gerard P. Kuiper of the University of Arizona, formerly of Yerkes Observatory at the University of Chicago, brought an Italian astronomer to visit our museum and, although we had closed for dinner and I was alone, I opened up and we had quite a lengthy session. Neither of the two visitors felt they could accept my theory of the lunar origin of tektites. The next day Kuiper came again, and I read to him two pages of facts about the moon and meteorites that I had jotted down as an aftermath of our discussion. These seemed to weaken his disbelief.

He asked me what support we were receiving from the government or from universities. I told him, "None."

"I think it is entirely proper that you receive the help that will enable you to finish off some of your important research projects and to write them up. You have more information than any other man in this field and it would be a shame for you to pass on without leaving this in a usable form for future generations."

He encouraged me to approach the National Science Foundation for a grant for research with part-time salary. Other scientist friends recommended that I seek support from the Office of Naval Research and Army Ordnance; both these departments indicated interest but nothing ever developed. Another proposal was that I apply for funds to make a round-the-world flight in search of craters.

I was tired of applying for grants, but decided to make these new efforts.

They all came to nought, but the suggestions were indicative of an awakening interest in things meteoritic.

With a generosity of understanding, coupled with a regret that Harvard found itself unable to acquire the collection, Fred Whipple had written, in 1951:

> I think it would be very unfortunate were it necessary for you to decimate your collection in order that you yourself should survive. Obviously it is more important still that you survive.

In late 1957 and early 1958 it seemed that we finally had arrived at the point when we would have to put our survival first.

In 1956 Max Hey, curator of meteorites of the British Museum of Natural History, had attended a meeting of the International Geological Congress in Mexico, and had stopped at Sedona to examine the collection. He suggested that the British Museum might desire to acquire a large part of it. The following year that institution asked us to submit an extensive price list of specimens that would amount to a "vertical split" of our collection.

In January, 1952, we had invoiced the specimens listed in our *Catalog,* exclusive of some duplicate and storage material, at $258,000. In applying the British Museum's request for a vertical split, and taking into account expenses of cutting and preparation and the fact that *division* of material did not destroy by half the value of the resulting parts, we selected 276 out of our 680 falls, of which we offered divisions of one-fourth to one-half, or smaller, at a total price of $155,000.

The British Museum was interested in obtaining material both for display and for various researches. Those responsible for meteorites at the British institution informed us that our list of offerings with prices was acceptable, but asked for time to look into the problem of raising money for the purchase. We agreed to await their final decision, which would be determined by their success in searching for necessary funds.

Before final acceptance by the British Museum, there suddenly was a surge of interest on the part of both the Arizona State University at Tempe, and the Smithsonian Institution. The two American institutions also were dependent upon finding funds. Arizona State particularly had no resources at its disposal and would have to locate outside assistance. The Smithsonian indicated an interest in buying the collection outright and, with no time to make any revised inventory, we simply guessed that $200,000 would be about right for a discounted price for the collection as a whole, but we made it clear that a prior offer was pending for a portion of the collection.

All three parties were informed of the various offers, without any of them being named, and were told that we would deal with the first to come forward with a firm proposition. There was no attempt to induce any competitive bidding, but our hope was that the collection would remain in the United States and our preference was that it would go to Arizona because of the importance of the crater to meteoritical research.

E. P. Henderson, curator of meteorites for the United States National Museum (the museum of the Smithsonian Institution) prepared a prospectus seeking support of the National Science Foundation for purchase of the Nininger Collection. The prospectus described in detail the contents of the collection: Total number of falls ("more than 727 meteorites, almost as many as are in the National Collection [850]");* number of witnessed falls—about 150; inclusion of many stony meteorites, two of which, at weights above 700 pounds, were larger than any in the National Collection; and other features.

> The collection contains a number of described specimens and many that have been so widely illustrated that such specimens are well known to students of meteorites.
>
> It contains numerous individuals showing flight markings. These features are of considerable interest because they help us understand the flight of solid objects through space. This subject is of special importance in guided missile studies.
>
> The collection contains a number of meteorites showing how heat penetrated them during their flight through our atmosphere.
>
> The Nininger Collection contains a fine series of specimens showing the effects of weathering.

It was gratifying to see the points made in favor of my series in flight markings, weathering and heat effects. Henderson's report also included a note on "The Building of the Nininger Collection":

> The Nininger Collection represents a lifetime of effort on the part of its owner. Against the advice of many of the best students of meteorites, when he began his life work in the nineteen twenties, Nininger demonstrated that he could support himself by prospecting for meteorites. This was a courageous undertaking because meteorites were considered to be very rare, widely scattered and extremely hard to find. Nininger proved that they were widely scattered but could be found if an intelligent search was made . . . .
>
> Nininger, and his wife, went into the field and lectured to local groups on meteorites . . . . The Nininger family lived by the sale of some of the material collected. Thus, they were able to continue their search for meteorites and to build up this great collection. Their

*Note. We claimed only 680 falls.

living was never without financial difficulties and after twenty-five years* Nininger is faced with the need of selling all or part of his collection to provide his economic security.

It should be remembered that, although Nininger supported himself on the sale of duplicate material and sections of some of his unique specimens, he faithfully saved the best material for his collection. The only exception to this policy was the sale of an occasional specimen to the United States National Museum . . . .

The prospectus included two comments that were, to my view at least, eyebrow-lifting:

> Mr. Nininger has passed 70 and is in failing health, thus his active pursuit of meteorites is over.**

and

> Personal bias or animosity has no place in the management of the National Museum. Thus, qualified persons cannot and will not be denied access to the National Collections. Denial of access is possible if the Nininger Collection remains in private hands.

Henderson found "fair and reasonable" the asking price of $200,000, payable in annual installments of $20,000. He gave as his own rough estimate of the value of the collection a figure just under $300,000, and added that "By individual pricing this collection of meteorites and adjusting values for the deflated dollar a fantastically high figure can be obtained."

After correspondence and delays and cross-correspondence and more dealys, it began to appear to us that the American institutions were going to be too late.

Under date of June 13, 1958, came a letter from G. F. Claringbull, keeper of the British Museum, with a firm offer to buy the approximately 1,200 specimens of the vertical split—about 21 per cent of our entire collection—at our named price less a seven and one-half per cent discount —$140,000. We cabled confirmation as requested. Also, we promptly withdrew all other offers.

Addie and I were somewhat shaken. After so many years of financial strain, and after having been driven to seek an institutional home for our

***Note. Thirty-five years was the correct time.**

****Note. As of this writing the Henderson prognosis is eleven years old, and I have made eleven strenuous trips outside the country: The Far East; Australia a second time; Europe twice; the Mediterranean; Central America; Baja California twice; Alaska; British Columbia twice.**

collection, offering it even at a fraction of its value with no takers, suddenly it appeared that we were to be able to have our cake and eat it too—the price received for a portion of the material would be sufficient to pay off our indebtedness and still leave working capital that might make it possible to arrange satisfactorily for continuing our museum operation.

We had never desired to see any considerable part of our meteorite collection go out of the country. We expected that we might face criticism. We were not prepared, however, for a telephone call from a man claiming to be representative of the Smithsonian Institution in Washington warning against our removal of supposedly "strategic" materials from the country, for we knew that officials of the British Museum had written to the United States National Museum to ask specifically if there was objection to British purchase of a part of our collection.

This telephone call, with the implied threat of an embargo against shipment of meteorites, came in the midst of our crating and packing of specimens. There was no further interference. The call apparently was an intended bluff.

Meteorites were not then, nor are they now, classified as strategic materials; their export therefore is subject neither to license nor embargo. This knowledge, however, did not prevent feelings of shock and some despair on top of what already had been a somewhat rending experience of giving up a large portion of a collection it had taken half a lifetime to accumulate. It had not been many years since, in desperation, I had offered the entire collection to this same institution, at a fraction of what now was to be received for a fifth of it.

Shipping preparations took the entire summer of 1958. We could not agree to a literal, complete vertical split of the entire collection. Many of the precious and scientifically most important specimens were too small to share. We divided many of the larger individuals, and we sent the main mass—more than 600 pounds—of Morland, retaining our other large stony meteorite, Hugoton.

The division of the several large stones and irons meant weeks of sawing. Since we had given up our large saw upon leaving Denver, we had to haul a dozen of the largest to a California laboratory capable of handling them. Cutting was not the greatest chore. Everything had to be carefully weighed and labeled. Our catalog records had to be amended. Our contract called for compensation for loss in cutting, grinding and polishing; this meant measuring and re-weighing everything and calculating the difference. Since some of these small specimens were priced at more than their weight in gold, this had to be done with precision. Each specimen had to be individually wrapped in a manner suited to its particular requirement. Some meteorites are so fragile they require utmost protection. Boxes had to be constructed to conform to the requirements of different types and sizes of specimens.

We handled the big Morland stone like a baby. We sheathed it in a plaster of Paris jacket, reinforced with burlap, and then built a crate around it. The plaster must not make direct contact with the stone, or it would be practically impossible to clean. Too, plaster reacts with the metal in meteorites and sometimes causes difficulties. So before the plaster coat was applied, the big stone was carefully swaddled in plastic.

Our decision had been made; the summer-long activity necessary to implement it gave us not much leisure, but a constant parade of recollection of finds and purchases, incidents and researches.

When the first partial shipment of meteorites was in transit to England we turned our thoughts to the comfort that for the first time in our lives we would be able to pay all bills due without using every available cent. Over the years we had built up a considerable file of investigations we would like to make overseas, and of meteorite collections and craters we should like to view. I was in my seventy-second year, but it was not my thought that my days of collecting and studying meteorites were over. We determined to take prompt advantage of our time and fortune, and forthwith laid out an itinerary of prime target areas for investigations, then talked with travel agencies to learn ways to reach our objectives and sightsee as we went. We made our plans, obtained passports and innoculations, made reservations and purchased tickets at what seemed a whirlwind rate. When the first payment arrived on September 11, 1958, Addie wrote checks until she risked writer's cramp. We enjoyed a social hour to celebrate paying off' the mortgage, and after writing just a few more checks we were out of debt for the first time in thirty-five years.

*Traveling is no fool's errand to him who carries his eyes and itinerary along with him.*

*—Amos Bronson Alcott, Table-Talk*

# 13. SLOWING DOWN

After shipping the remainder of the British Museum purchase, on October 26, 1958, we sailed from San Francisco for a six-month Far East tour heavy with stop-overs for field work and visits to institutions.

Shipboard is a nice way to travel, but we found ourselves growing a bit lazy. I seemed able to sleep almost any hour of the day and to sleep all night. I lectured twice aboard ship and suggested to the captain that shipboard might be a good base from which to measure meteoritic dust. He provided a dozen unused white plastic waste baskets which the ship's carpenter helped anchor forward of the bridge. These were left undisturbed for six days. When I carefully examined them, I found an amazing amount of dust—too much, I thought. I told the captain the results were almost too good to be true, and the material would of course have to be investigated later in a laboratory, but we agreed it was only fair that I should report the results to his staff. I emphasized the importance of any positive results and their possible bearing on our space exploration, and I praised the men for their cooperation. After dismissal of the group one of the men asked to see me privately and, very apologetically, he spilled the fact that he had salted my catch with some dust from the machine shop!

Throughout the Orient we were met, entertained and escorted by local scientists or university, or museum men. In ajapanese home in Kasamatsu, Hashima, Gifu Prefecture, we were served tea by a lady who displayed a meteorite that had fallen into her house in 1938, and showed us where it had gone through the roof. We toured museums and universities everywhere.

Secondary to our interest in displays of meteorites and purchase of some specimens, was our interest in tektites, those strange blobs of glass that are found only in certain locations on earth and whose origin still is in doubt.

I first acquired a small collection of tektites in the early forties.

Many explanations have been advanced for the origin of tektites, including theories that they are of human manufacture, are glass meteorites, nodules from "light metal" meteorites, products of lunar volcanoes, or remnants from the deeper crustal layer of earth set free by the hypothesized separation of the moon from our planet.

In 1938 Dr. Virgil Barnes proposed that tektites were the product of lightning striking in certain types of soil on the earth and this theory enjoyed a considerable following for several years. Dr. L. J. Spencer of London theorized that tektites were a form of impactite produced by crater-forming meteorites on the earth. A number of eminent physicists now think that very ancient and very large meteorite impacts on the earth produced tektite glass which was thrown into temporary orbit and returned as tektites.

Tektites have been known to occur on only a few areas of the earth's surface, all of these locations, with one exception, lying within an equatorial belt eighty degrees in total width. Though they have differences one from another, tektites are strongly similar, and those found in a particular region have common characteristics which differ somewhat from those found in other localities. It seemed to me that tektites fit into the picture of intense and violent bombardment of the moon by meteorites, with resultant scattering of the lunite rock to great distances and at great velocities. In February and March, 1943, *Sky and Telescope* carried a two-part article, "The Moon as a Source of Tektites," in which I outlined my theory that tektites are fragments of lunite (the shattered lunar rock comprising the surface of the moon) which have been set free from the gravitational force of the moon and then have fallen into the stronger gravitational pull of the earth. In 1947 I set forth this theory in expanded form in a paperback booklet, *Chips from the Moon,* published by our museum.

These odd disks and buttons and dumbbells were high on our list of things to explore, and our Far Eastern itinerary included three of the most heavily strewn tektite areas.

It was an exciting privilege to meet, in Manila, Dr. H. Otley Beyer of the University of the Philippines. Trained as a geologist, Dr. Beyer was sidetracked into archeology via ethnology and then, while pursuing a career as a professional archeologist, stumbled into tektites, first as a hobby and then so deeply that when we met him in his seventy-sixth year (1958) he had in his possession 500,000 tektites. He contributed some of the best papers to have appeared on tektites and all the while retained his reputation as the top man in Philippine archeology.

Dr. Beyer above all else is a field man. I had become somewhat impatient with the rapid growth of tektite literature, mainly produced by men who had studied a dozen or so tektites in the laboratory. It was very refreshing to meet a man who had collected a half million tektites from thirty or more locations on a single island and several hundreds more from locations scattered through a half dozen other countries, and who was not yet ready to offer a theory as to their origin.

The reason for this seeming tardiness in theorizing became obvious as one conversed with him and observed his work in field and laboratory: He knew too many facts. Always, just as he had about finished aligning his facts he found it necessary to examine another bag of specimens some individuals of which stubbornly warped the alignment. He chose not to label these the "exceptions that proved the rule" but rather went on patiently observing and comparing both tektites and their environments in the hope of finally discovering an alignment which the stubborn facts would fit.

Dr. Beyer was laboring under handicaps, living alone in a shabby upper-floor room to which his collection was moved prior to occupation of Manila by the Japanese. The lack of facilities and equipment would defeat most men, but he never uttered complaints. His work room and library had no electric lights and his windows were constructed of thin blocks of dingy oyster shell. On even the brightest days his room was so poorly lighted I could not have thought of working in it, yet he could point out structure and form in amazing detail. If we overstayed the five o'clock closing time even a few minutes on the December evenings we spent with him, we had to find our way out through a maze of halls by feel or by flashlight.

Next, we went to Saigon because we knew that tektites had been found in South Viet Nam when it was a part of Indochina. They had been labeled "Indo-Chinites" by Professor Lacroix, the French tektite authority who first described them. Our only hopeful contact in that little country was Professor Edmond Saurin of the University of Saigon. Could he tell us where we might search?

"In the city of Dalat, about 150 miles northeast of here, between the Old Church and the Hospital Civil. We found a considerable number right in the road."

His classroom duties made it impossible for him to go with us to Dalat. Since it seemed hardly likely to us that we would find collecting to be as simple as the good professor seemed to expect, we sought out a conveyance and a driver who could not only transport us to Dalat, but serve also as guide and interpreter. We hired an English-speaking employe of our Saigon hotel who, with notebook and great eagerness, began to outline a lengthy plan for visits to all the shrines and places of interest of Dalat, and who was quite crestfallen when I explained we were seeking a peculiar kind of rock and had no time for sightseeing. He brightened as he began to list museums and mines where we could find rocks, but again I interrupted to show him a sample tektite. Quite unenthusiastically he drove us along the road to which Professor Saurin had directed us.

Unfortunately for our purposes the road now had been paved, but we searched the narrow shoulders and canvassed the houses along the way, showing samples and asking for information, with no results. We seemed almost at a dead end when a young fellow told us that "we could get lots of that up at the university." I suspected that he was referring to a display of tektites and so we turned our car toward the institution at the edge of town. As we approached the entrance our guide stopped the car on a blacktop area and pointed to the tar-coated pebbles.

"Ah, there are the tektites the boy saw," he declared.

I was afraid he had made a good guess, but I got down from the car to look about. In a cut bank I noticed a zone of laterite pebbles (laterite is a brick-red, gravelly formation characteristic of most tropical countries) and I recalled that Dr. Beyer had found Philippine tektites associated with such a deposit. I scanned the bank and there, protruding from among the laterite pebbles, was the end of what appeared to be a tektite. I quickly removed the inch-long, grooved fragment of black glass. It had the characteristic appearance of Indo-Chinites of seeming to have been stretched while in a molten condition.

The guide and Addie quickly joined me and the three of us carefully scanned the cut banks along the road, each of us finding one or two specimens. Then the laterite disappeared. We looked along a crossroad and saw in the distance quite a lot of new road construction traversing low rolling hills in which the cut banks showed clearly the brick-red hue of laterite. We headed in that direction and as we came to the low hills tektites bagan showing up on the road shoulders where they had been washed free by recent rains, and in the banks and ditches. The three of us scurried about finding more tektites than we supposed ever had been found in one locality. By the end of three hours we had gathered more than 300, and with our guide enthusiastically producing his share, we gathered teardrops, elongate teardrops, dumbbells and disks, ovals and hollow tubular forms, mostly fragments but some complete individuals.

The next day we worked another four hours and took back to Saigon a total of 825 pieces. Our guide was a complete convert to the hunt, and he continued for years afterward to find and ship tektites to us, thus making a better living than his job had provided.

The great island continent "down under" was the big goal of our trip. We had scheduled a two-months stay in Australia, for a long trek into the outback to visit meteorite craters and to search for the Australian tektites, Australites.

With Allan Kelly, a geologist friend from Carlsbad, California, we purchased a Volkswagen Combi-Van and set out on a seventeen-day, 3000-mile drive into the interior, largely a barren land with few roads, most of them poor. Scarcity of water plagues the greater part of the continent and accommodations in the outback are minimal. We carried camping and cooking equipment with us.

From Perth we traveled north through 300 miles of wheat country somewhat like our own western wheat states, though the "stations" or farms are much larger and the towns smaller and farther apart. The harvest of 1959 had been a good one (wheat being harvested in January this far south of the equator) and every little town had bulging granaries and great open bins filled to overflowing. Large flocks of beautiful rose-breasted, gray parrots were feeding in the open bins, almost completely covering the mounds of grain. When disturbed they arose in great gray clouds to alight on the telephone wires nearby—such large, heavy birds that balancing on the wires was so difficult that many hung by their bills or feet.

There was practically no traffic; in 355 miles we saw only two cars and one motorcycle.

We stopped in the villages and towns, inquiring as to where tektites might be found. We talked to science teachers and other local "identities." No one seemed to have any tektites, but nearly everyone had heard of them. "Yes, you find them in the bush." "They can be found on the Nullarbor." "You find them on the dry salt lakes." "A lot of them have been found around Kalgoorlie."

On the outskirts of nearly every village were the aborigines' camps, clusters of makeshift shelters made of brush, or a blanket or canvas spread over a low bush. Occasionally a camp was set up out in the bush, some distance from any village or town. In each camp we showed our tektite samples to the natives. Often they were shy and wary, but occasionally, after persistent questioning, someone would produce a tektite from somewhere on his person and be persuaded to part with it for a few shillings. All seemed to be familiar with tektites, but showed a "What of it?" attitude. Years ago, tektite collecting and trading by the aborigines had been a general practice, but as the government began to look after their needs, the natives saw no further advantage in searching for the bits of glass. Occasionally we were directed to a large cattle or sheep station. Usually we got pretty much the same answers to our inquiries. "I used to have a lot of them but they were no good for anything and I gave them to the kids. They're all lost." "I had a whole cigar box full but I threw them out. Nobody wanted them." "Years ago there were lots of them."

An exception was the 640,000-acre station of Mr. Barton Jones near Kalgoorlie. Here the family had made a practice of preserving all of the tektites found on their ranch, and over a period of forty years had amassed a collection of 1,166 specimens. Mr. Jones admitted that he had seen less than half of his ranch and that most of it was still "bush." In view of the fact that they had simply collected those tektites which they came across accidentally, and those were recovered at a rate of slightly more than two per square mile, they must represent a rather small fraction of the total number present in the soil. We purchased the marvelous Jones collection entire, but still we made no finds in the field.

Countless times we stopped in likely looking areas of barren soil, blown fields, sand dunes, openings in the bush, where we walked about scanning the ground. We were camping out every night, and as we made camp and gathered firewood we scrutinized the ground carefully. We never walked anywhere without looking at the ground, but never a tektite did we see.

From Kalgoorlie our way lay across the great Nullarbor Plain, which most Australians know only as an area to be flown over, or crossed by train. We were told that we were foolish to try it by car. The road was rough and sandy, the terrain barren and treeless.

We loaded our van with supplies, including gas and water sufficient to carry us the entire 1500 miles to Adelaide on the eastern edge of the Nullarbor, and started off*. The trek across the Nullarbor, a region resembling the Navajo reservation country of Northern Arizona, took five days. All the time we continued our individual searching of the ground whenever we stopped; still we arrived at the end of our journey without having found a single tektite in the field.

Later I discovered in talking with scientists in Melbourne and Adelaide that very few Australian geologists have ever found a tektite. An exception is Dr. George Baker of the University of Melbourne, whose curiosity twenty-five years ago led him to explore an almost inaccessible, rapidly eroding slope resting precariously on a vertical cliff that plunges into the sea. Here, where other men had seen no reason to venture, the normal deposit of tektites has remained, a few being set free by erosion each year. Dr. Baker makes regular excursions to this "private" hunting ground, gleaning a few choice specimens each trip. In twenty-five years he has thus gathered more than 800 Australites.

Dr. Charles Fenner, who spent many years studying Australites, and who by gift and purchase amassed a great collection in the Museum of South Australia, estimated that from one to ten million tektites had fallen in Australia. This seems a large number until one reflects that the portion of Australia within which specimens have been found comprises some 2,000,000 square miles. An average of two or three little tektites on each square mile is spreading them out pretty thin. It is no great wonder that our brief expedition made no finds.

At Adelaide, 1500 miles from our starting point, we disposed of our car and camping equipment, and flew to Alice Springs, the kickoff point for side trips to the meteorite craters. The Alice Springs country was hot, insect-ridden and suffering from prolonged drouth. One station had lost

5,000 cattle. There was absolutely no forage left except leaves on the trees; it was hard to visualize this country green and lush as we were told it would be in the "wet."

The Australian Bureau of Mining furnished cars and drivers for a one-day excursion from Alice Springs to the thirteen Henbury craters. I found spheroids, a number of small meteorite fragments and some impactite. We purchased additional meteorites from the widow of the man who had supplied us with Henbury specimens many years before.

At the small Boxhole crater, a pit some 500 to 600 feet in diameter, 150 miles from Alice Springs, we found no meteorites.

To reach the Wolf Creek crater, Australia's largest, two-thirds the diameter of Arizona's, it was necessary to fly to Hall's Creek and from there drive a hundred miles by jeep. Because the trip would be so rough Addie was strongly advised not to go and finally consented to remain behind.

The jeep trip required seven hours. The last nine miles and four.hours were through a kind of spiny grass called *spinifix,* whose tight sod hummocks grew six inches high and two to twenty inches apart. The jeep bucked along like a galloping mule with a broken leg. Wolf Creek, as expected, yielded many fragments of oxidized meteorite.

Dalgaranga is the sixteenth of the Australian craters. We had visited this medium-sized crater on the third day out in our Combi, which we chose to call the "Kangaroo," and had found some small meteorites. I was surprised at the scarcity of material, since this beautifully shaped, well-preserved crater was little-known and little-visited. I determined to return at a later date with a detecting device and a man and equipment to excavate. After our return to Sedona we were surprised, on polishing one of the little Dalgaranga specimens, to find it was not a medium octahedrite, as described, but a mesosiderite. Other specimens were like it; some others were true siderites; none fitted the published description.

The Museum of Western Australia endorsed our plan to extend the surface search and excavate to some extent within the Dalgaranga crater, and my son-in-law Glenn Huss and I returned the following October. We collected 207 specimens, all quite small, a third averaging about one-ninth ounce and the largest weighing two ounces. All of the larger ones were completely oxidized. When later we cut and polished more than half of the specimens, they showed a variety of composition—most were siderites; some were mesosiderites and others a combination of siderite and mesosiderite; two were aerolitic (stony). Many showed deformation by pressure and some showed heat alteration. The material from within the crater itself was badly disintegrated and oxidized and bore no resemblance to the meteorites found on the surrounding plain. We theorized that the crater was made by a mass of ten to twenty tons, predominantly stony, which was thoroughly shattered and which for the most part has decomposed.

## 2

When Addie and I left Australia we had been away from the United States five months. Only visits to New Zealand and Hawaii and the long sea voyage lay between us and Los Angeles harbor, where we docked May 14, 1959.

We had arranged for purchase of a hilltop site while we were away and had approved plans for building a home. Until it should be finished, we went back to trailer life; Margaret and Glenn Huss with their family were living in and operating the museum.

We found the museum just barely carrying itself. We would have to make a final decision as to ours and the museum's future.

Once more I ruminated with myself for long hours over the alternatives of closing and remaining open. The sale of the first portion of the collection had given us a breather, but it was plain our problem was not solved.

I wrote memoranda to myself: "Why the Meteorite Museum Should Not be Closed," "The Future of the Meteorite Museum," "The Program of the American Meteorite Museum."

Even with the removal of the great number of specimens acquired by the British Museum, the worth of our exhibit as an educational instrument had not suffered appreciably.

No visitor ever went through our little museum without opportunity to ask questions. Because our whole effort was devoted solely to meteorites it was possible to concentrate and absorb in a fashion that is impossible in the ordinary museum, where hundreds of different subjects are presented.

We brought to the general public opportunity to see and handle meteorites in their natural condition, just as they are found in the field; we furnished verbal instruction with special emphasis on those facts that would enable agricultural and other outdoors people to recognize meteorites. We carried on continuing field work, thus not only adding to the material available to view, but enlarging the fund of knowledge concerning distribution of meteorites. We exhibited the widest possible variety of meteorites both in their natural form, displaying such surface features as fusion crust, pitting, orientation and flight markings, and in cut, polished and etched slices, showing interior structure and components.

What would be the source of materials in the future? The majority of all the meteorite finds of the past generation had directly or indirectly resulted from the educational program carried on by our laboratory, first, and our museum, later.

I did some multiplying. By my figures, the museum had served a half million visitors during more than 4,600 days of operation since October 19, 1946, and the verbal instruction given to groups of two to fifty would equal nearly 7,000 one-hour lectures.

Our last hope had been that the museum could pay its way and support

Margaret and Glenn, who would operate it, leaving us free of its burdens and attendance and care. But it was apparent it could not. We inventoried our remaining collection, this time using the data of our sale to the British Museum as a guide to value. Our resulting invoice was a lesson on the importance of taking time for inventory, for it showed, on that basis, a value of more than $530,000.

By Thanksgiving Day, 1959, we were moved into our new house atop one of Sedona's red hills, our first real home since leaving our rented house in Denver.

I helped the workmen select lichen-covered stones for both the interior and exterior rock work of our bright, contemporary home. Addie shopped for furnishings. The delight of our house was our hungry fireplace for which we sawed and hauled firewood from the hills.

In the fall of 1959 Arizona State University at Tempe again indicated a desire to acquire the collection. New and sudden interest in space, missiles, rockets and satellites had made meteorites the obvious and most probable source of information vital to progress in all of these fields. Addie wrote to one of the children that "scientists are *hounding us to death* for material we don't want to part with." As the requests for material and information kept multiplying, we felt it would be almost tragic if we should drop out after all of our struggle, just as the long years of effort seemed to be fruiting. On the other hand, the time was late for us; we concluded that we really had no choice.

We indicated that we would be willing to dispose of the collection to Tempe at about half its catalog value, but that we might move to offer the collection out of the state if definite interest was not shown soon.

Glenn and I returned from the second Dalgaranga trip in October. At the end of November I made a quick flight east for lectures at the Massachusetts Institute of Technology and Harvard.

In accepting an invitation from the Departments of Metallurgy and Geology at M.I.T. to speak before "interested persons," I wrote that my chief interest always had been and still was "to see a genuine, broadly conceived and well financed program of meteoritics." I added: "At this stage of the game I recognize that meteoritics has outgrown me in many of its aspects, for which I am greatly delighted. However, I am constantly being reminded that there are at least a few aspects of the subject wherein my years of critical observation can be of considerable use to the technological and the specialized researcher." My topic was "A National Program of Meteoritics."

At Harvard I addressed a group of scientists representing eastern universities and governmental agencies who were concerned with building an active program of meteoritics. Here, my subject was "A Plan for a Nation-Wide Coordinating Center for Meteoritical Research."

Most of the proposals I made at Harvard on December 2, 1959, were not markedly different from plans suggested in the past or from actual methods of field work of our own program, only updated.

In *Popular Astronomy,* November, 1933 I had outlined a suggested program of research on meteorites. In 1935 I published a plan for a "Proposed National Institute of Meteoritical Research."* Then, twice more, in connection with the effort of Denver businessmen to establish an American Foundation for Meteorite Research and the plan presented to the Penrose Foundation, I drew up detailed suggestions for a coordinating research program. My book *Out of the Sky* carried similar recommendations in 1952.

With the coming of the space age, it seemed there were more listeners and perhaps a greater willingness to undertake such a program. One suggestion in particular, almost identical to a suggestion of 1935, attracted interest—a plan for thirty batteries of four automatic, wide-angle cameras, to be set up at distances of 300 miles over the entire nation and, if feasible, a cooperating sister network in Canada. The cameras of each battery would face in four directions in order that any fireball of important magnitude could be promptly and accurately triangulated.

I suggested also a parallel plan for a lookout network of fireball observers, to consist of correspondents in principal universities and colleges, the U.S. Forest Service, airport control towers, the U.S. weather bureau, the air force and other similarly situated individuals who would report fireball sightings to a central control center.

I presented the same "Plan" before the "Space Science Board" of the National Academy of Sciences at the California Institute of Technology December 14 and 15, 1959. Following the Caltech presentation, Dr. Harold C. Urey requested and received mimeographed copies; others were sent to Fred Whipple, who requested further information on methods of implementing the program. Written appreciations for the filling of both these requests rest in my file.

Published accounts the next year, I960, of the initiation of a nationwide search for meteorites with the Smithsonian Astrophysical Observatory at Harvard as the organizational center, credited the "launching" of the program to a meeting of the Meteoritical Society the previous September. No mention was made to me during the brisk question-answer period that followed my December talk at Harvard of any previous such discussion at the Meteoritical Society meeting.

The "Prairie Network" for observation and recovery of fireballs covers the plains area of the nation with camera batteries set at intervals of 150 miles. It is the sort of thing that I longed for back in the thirties when I was exhausting all of my resources in trying to plot the course of meteors from the testimony of witnesses who had only accidentally seen the

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phenomena and none of whom ever had opportunity to make an instrumental record of what they had seen.

Even with functioning of the Prairie Network of cameras, with advance preparation for accurate plotting of the courses of meteors, the recovery of meteorites from fireballs still demands that field workers have a very thorough training in the most elementary aspects of meteoritics, namely a complete familiarity with all of the known varieties of meteorites and a good understanding of the methods of carrying on effective search.

Early in 1960, interest in purchase of the collection heightened at Tempe again, and then again it slowed. In the spring, finally, we sent to a small number of major institutions a brief announcement that the Nininger Collection of Meteorites was available for purchase. This stirred up a good deal of activity and brought an inquiry from abroad of which we notified the National Science Foundation in May, since the university at Tempe pinned its hopes for financial help on the N.S.F. The Foundation assured us of definite plans to buy, but in June they still were moving very slowly and had imposed restrictions which we feared could take the collection out of Arizona. By now it had become my firm wish that the meteorites remain in the state, but I threw up my hands, ready to start all over again.

Letters from Frederick Leonard of U.C.L.A. during this period reflected that he and I were sharing some of the same emotions as life was advancing and, with it, at a pace a little fast to keep up with, the science of meteorites in which we had taken such a keen and sometimes lonely interest.

> "There seem to be a great many people these days who are working on certain *phases* of meteoritics," Frederick wrote. "I cannot help wondering, however, how seriously interested they are in meteoritics *as a whole* or in meteorites per se. . . .
>
> "I wish that it were possible for me to sit down with you and have a long conversation on a number of matters meteoritical. . . . In spite of all the activity that seems to be going on at present, I must confess that I have mixed feelings in regard to some of it, and that at times I am downright disturbed about the future of meteoritics in this country. I wonder whether you have similar reactions or whether you are more optimistic. Unfortunately, the old-time meteoritics (of 25 or 30 years ago) seems to be disappearing; who for instance, is going to carry on the field work that you have done—and who is interested in meteorites for their own sake and not simply in the answers to certain restricted problems that may be obtained from studying them?"

Under date of March 24, 1960, Frederick offered some suggestions of additional institutions and individuals whom I might notify of the availability for sale of the remainder of the collection. He expressed a hope that the collection might remain in the United States, preferably the west, and added,

> "Altho I have nothing against the British Museum, I cannot help regretting, as a loyal American, that it acquired 21% of your collection—but you obviously were not to be blamed for selling it to them, if they were the only prospective purchaser!"

Frederick was looking forward with mixed feelings to retirement in another three or six years. He remarked that were I to become financially independent I should be able—and he quoted from a letter of mine to him—to " 'get many of the things done that have lain unfinished through the years.' "

He added, "I wonder whether we do not all feel that way ..."

The following month, April, 1960, Frederick brought his two young sons and a class of students for a visit to the museum and the crater. He and I had made many field trips over the years, including our trip into the California wilds when he ecstatically hugged the great Goose Lake iron, but this was the last; he hoped to return for a week in August, but his final illness interfered. He died in June of that year.

Addie and I wished to attend an International Congress on Meteoritics in Copenhagen in August; our son Bob planned to attend a Geological Congress in the same city at the same time. We decided to close the museum immediately and to begin packing the collection. If a sale came through, it would be that much nearer ready for shipment; if not, we would store the meteorites, and sell or rent the building. We went right ahead with plans to sail from New York July 21.

Suddenly the slow-grinding institutional mills completed their operation, and the remaining majority of the Nininger Collection was assured of a lasting place in the halls of Arizona State University at Tempe, at what we considered a fair price, $275,000, far below the listed value.

Four days later, Margaret and Glenn and their family followed their belongings to Denver for a new life, and to carry on the name and work of the American Meteorite Laboratory. That evening, Addie and I went to Phoenix, to catch a flight to New York for our sailing date Thursday.

An era was over. The museum was gone.

In four months we toured fourteen European countries, combining usual sightseeing goals with visits to universities and museums, examining meteorite and tektite collections. We listened with pride as Bob discussed the genesis of uranium deposits before the international gathering of geologists in Copenhagen.

The Munich collection of meteorites had been destroyed in the war, but Vienna had a marvelous collection which we photographed extensively.

Prague, too, had meteoritical information, and the university there provided us with a guide who drove us 150 miles to visit the tektite fields. Near Tubingen, Germany, we were escorted by a university faculty member to inspect the nearly circular valley of Nordlingen Ries (Ries Kessel), about twenty-seven miles across, since proven to be a meteorite crater by the finding in its walls of coesite.

While we were tracing information about an important meteorite which fell in Zweibriichen, Germany, some ninety years ago, we stumbled into what seems to be the ancient abode of the Niningers. The name is prominent in the village of Bad Durkheim and appears several times in the Manheim telephone directory. It seemed consistent that a meteorite hunt should end at a dwelling place of Niningers.

From Strasbourg we made a prized excursion to the little Alsatian village of Ensisheim, where a large meteorite had fallen about the time Columbus landed at San Salvador. The meteorite had been pronounced a "miracle" by the clergy and other wise men of the place and time and is preserved to this day. The stone no longer is kept in the church, but in the *rathaus* (town hall), in a little upstairs "museum" that holds a few old records, an implement or two and a few relics. We were led to the meteorite by a plump little lady about four feet six inches tall, who scurried about through several rooms of the small city hall until finally she emerged with a huge key. Waving this at us, she led us down the stairs and across the street and upstairs again in an older and more ornate building, where we followed her up worn granite steps to a room which opened to her huge key. Here was her museum, with the meteorite displayed in the center of the room, lying atop a rickety old pedestal, covered by a glass top. Nearly all the fusion crust is gone from the stone, and all of its prominences have been knocked off, leaving it about half its original size and distorting the meteorite to a mound-like shape.

In Heidelberg we were guided by Dr. P. Ramdohr who, after showing us the small but important collection of true meteorites, opened a small cabinet drawer labeled *pseudometeorits.* Looking over this collection I noted that European scientists seemed to have been plagued by about the same array of mistaken identities as are those of us Americans who encourage the untrained public to send in objects suspected to be of extra-terrestrial origin. There were nodules of iron sulphide, magnetite, iron concretions, basalt and other minerals and rocks commonly mistaken for meteorites.

One small specimen caught my eye at first glance, but I waited until all the others had been examined before taking it up for inspection. (This is a habit of mine which I cannot explain. When I am in the field searching for a certain kind of specimen and spot one, usually I look all about it for any others similar before picking up the important find.) As I picked up that most important of the specimens contained in the collection of *pseudometeorits,* I said to the good Doctor Ramdohr: "Do you think this is a *pseudometeorit?"*

He looked at it, noted its number, then read the label in its small tray which bore on an attached pink tab the same number (96) as on the specimen, and answered "Yes," reading aloud the label: *"Pseudometeorit 108.47 q. Fund: 1909 in der Nahe de Lahnufers bei Marburg. "*

"Dr. Ramdohr," I replied, "I think this is a genuine meteorite of the pallasite variety."

Seeing that he showed no interest in questioning further the accuracy of the classification which had been assigned, I asked if he would allow me to take the specimen, cut it and return one portion of it to him with my own classification. It was agreed that as a *pseudometeorit* it really had no value and that in case my judgment proved correct it would constitute an important addition to the thirty-five falls and finds that had been recorded in Germany during the past century and a half.

I gave Dr. Ramdohr a receipt for the little specimen and upon return to Arizona had it bisected. It was revealed to be one of the most beautiful little pallasites on record.

3

March of 1961 found us back in Sedona, still settling into our new home, laying a hearthstone that boasted a fine series of tiny fossil tracks, and finding places for the small furnishings we had brought from all over the world to add a cosmopolitan flavor to the Indian and Mexican rugs and baskets and western paintings we had always favored. We spent a good deal of time unpacking, sorting and grading and repacking for storage quantities of tektites that our Vietnamese friend continued to send for our purchase.

We planted shrubs, geraniums, mounds of chrysanthemums, gillia, century plants, yucca, cactus, pyracantha for the wintering birds. Our entry and patio and the garden descending a steep hill behind the house began to flow with color against the red ground rock. At the side of the house wild white primroses congregated in a gleaming mass. Watering chores were never-ending; few things, other than the natural flora, could grow in that soil and climate without the attentions of hose and spray. Even inside the house my precious lichened rocks of fireplace and planter had to be kept moist. Care of living things is of itself rewarding, and I would rise early and have my chores well started and a walk completed by a respectable breakfast hour.

The frequent retirement problem of what to do with one's time bothered neither of us. We merely extended our old interests and found new ones. Addie discovered a new hobby. She had saved stamps over many years from our foreign correspondence; now she bought reference books


*American Meteorite Museum, opposite Meteor Crater on Highway 66 in Arizona.*

*Visitors studying exhibits at the Museum.*

and stamp books, dragged out all her old envelopes and packages of stamps and all those she had collected on our Far East and European trips, and earnestly set to work to build a creditable collection. I dragged out my old bundles and piles of manuscripts, some written as long ago as college, saved against the day when I might wish to set down an autobiography. I easily grew restless under the harness of writing chores, finding it difficult to work for more than two or three hours at a time. I had given up trying to learn the use of a typewriter years before, because my mind always raced ahead of my fingers so persistently that I was kept in a state of constant nervousness.

I doubt that the world holds another woman who would put up with such demands as my program placed upon Addie. When she accompanied me on field trips it was not merely for the outing. She helped with the driving, with field notes; and, whenever we were using a trailer, kept house and meals in readiness just as at home, while I dashed abodt after all sources of information, scurried off on strenuous field work or delivered a lecture or several lectures in a day. She expanded her activities as the children grew. Through the years from time to time we had living with us, besides our own three children, several nieces, several nephews, and also children of friends, who shared our home for weeks or months at a time.

Now there was an almost constant stream of visitors—relatives, former students, old friends, scientists—to our home on the hill. When there were not visitors, we often were away. In the summer of 1961 we drove to Edmonton, Alberta, Canada, to make a magnetic rake survey of the field adjacent to the Bruderheim shower of March 4, I960, for the University of Alberta.

This fall had occurred not far from Edmonton, and very near the village of Bruderheim, a Ukrainian settlement. At the time of the fall there was a six-inch snow cover over frozen ground. All sizable stones had bounced, splashing black soil in all directions that made their finding an easy matter. About 700 pounds was recovered, the largest fragment being seventy pounds. The farmers had noticed black dust or gray snow the morning after the fall, covering some of the ice of the broad Saskatchewan River and the fields just east of it. Searchers had gathered the meteorites, including several hundreds of small pea-sized stones.

Our purpose was to try to collect the meteorite dust, though it was now sixteen months after the fall. We spent many hours pulling our specially constructed little rake over the fields, but our efforts yielded only one tiny meteorite. Bruderheim is a stony meteorite; most of the dust simply was not magnetic.

Great areas, apparently hundreds of acres of snow had been gray with small particles, which sank to the bottom on the first sunny day after the fall. Had anyone considered this dust important at the time, it could have been easily and meaningfully collected. These small particles were the most important feature of the fall in my opinion.

There seemed now to be demands for my time and services from individuals and groups heretofore uninterested in the Nininger name and work. A request came for a list of projects to be submitted to NASA under the auspices of the Rocky Mountain Association of Universities. I was being pressed for a field manual on discovering and collecting meteorites. These requests, together with my autobiography, a proposed book of meteorites of the world, the cataloging of about a thousand tektites a month and a few other things seemed to be almost enough for a retired meteoriticist.

Two scientific meetings held in November, 1961, one in Washington, D.C., and the other at Pennsylvania State College, appeared to herald acceptance of theories I had advanced as far back as 1943, but which at that time had made no noticeable stir.

The Washington meeting was concerned with tektites, and drew a large crowd of interested persons—mostly of the United States Geological Survey. Only a few years before, that organization still was failing to recognize officially the existence of meteorite craters; practically the entire program on this occasion was devoted to the question as to whether tektites are produced on the moon or on the earth *by impact:* Not impacts of the size that produced the Arizona crater; but huge asteroidal impacts such as produce lunar maria.

At the Penn State meeting two days later I lectured on "Cosmic Blitz," presenting the matter of asteroidal impacts as the logical culmination of a fair factual consideration of observed rates of infall of meteorites of various size. My talk was so well received as to indicate that finally the idea had *arrived.*

Several of the speakers on the Washington program credited me for their present interest in tektites, and two went so far as to say that I had fathered the whole study of impact as the origin of tektites.

In February, 1962, when a symposium on meteorites was held at the Tempe campus, it was our pleasure to announce establishment at Arizona State of a $25,000 trust fund from which an annual $1,000 prize would be given to a student in any college in the country for the best research paper on meteorites. At the same time, Herbert Fales made a grant for education and research on meteorites. We enjoyed our continuing association with the university people. Dr. Carleton B. Moore had become director of the Nininger Meteorite Collection (later the Center for Meteorite Studies) at Tempe. Gerard Kuiper had left Yerkes Observatory in Chicago to join the University of Arizona at Tucson.

Our greatest satisfaction came from seeing the awakening realization among scientists that the general field of meteoritics is basically important, that certain aspects of this young science have vital bearing on problems that have plagued geologists and astronomers.

It seemed that the years of battle and the years for scoffing were ended. Long-eluded recognition and honors began to flow. The City of Denver honored me among other former citizens on the occasion of its centennial birthday celebration in 1958; McPherson College bestowed a special citation at commencement of that same year. I was granted a life membership in the American Association for the Advancement of Science. In June, 1963, Arizona State University awarded me an honorary doctor of laws degree.

4

How many hundreds or thousands of specimens, some of them unusual in type and spectacular in size, must there be in odd nooks and crannies of our world, of which at least a portion could be retrieved if a more general interest in a knowledge about meteorites were developed.

One of the largest, finest and most unusual stony meteorites yet discovered came from the Bondoc peninsula of Luzon in the Philippine Islands only because of coincidental events and the persistence of an ingenious American. Conditions for finding meteorites in the Philippines are very poor. Most of the islands consist of rugged, heavily forested volcanic mountains. The combined 7,000 separate islands constitute only one 570th of the earth's land surface, and very little of this is under cultivation.

The Phillipines had recorded only one meteorite besides the witnessed fall of 1938 at Pan tar, Lanao. The man who had given most attention to meteorites in the islands had been Father Miguel Selga, a priest whose collection had been lost during World War II. Father Selga had since died, and I was positive that many Filipinos must have encountered meteorites. We had been in the Philippines ten or twelve days in 1959 when I visited the office of the National Bureau of Mines, sure that among the thousands of samples that inevitably reach such an office, there must be an occasional meteorite. The only question in my mind was: Would a meteorite have been recognized and saved?

"Well, yes, once in a while such a sample comes in; but who cares about meteorites?"

I had the answer.

Might not the Bureau have such specimens on hand? Well, the director thought, there should be *one.* It had come in not so long ago; he sent a girl to find it. She failed; another young lady was dispatched. The second messenger returned shortly and handed over the specimen, a rounded, rusty lump of what appeared to be nickel-iron, very badly weathered. Despite its unusual shape—meteorites almost never are round or even approach that form—it obviously was meteoritic. The lump had some stony matter adhering to one side. This fact, together with its rotundity and the statement by the Bureau official that the lump had been found to contain nickel and that it had been detached from a large mass, set my mind to racing.

The official assured me the Bureau had no interest in the specimen and that I was free to pursue the matter.

The sample had been brought in by a prospector as evidence that he had found an iron deposit, and the case had been duly referred to Senator Tanada of the Philippine Congress, whom I thereupon visited. But this gentleman had transferred the matter to his son, a lawyer, whom I now called upon only to learn that he had invited his friend Mendoza, another young lawyer, to share the new prospect with him, for Mendoza lived very much nearer to the location of the deposit, described as in a remote jungle far down the Bondoc Peninsula.

The pair of lawyers had contacted two Japanese geologists who desired an iron mine, but when these two were escorted to inspect the prospect they were disappointed and disgusted. This was no iron outcrop, exploded the Japanese geologists, but only something that had fallen from the heavens, and they turned away.

Perhaps the state of mind and muscles of these two geologists should be considered against the background of the ordeal required to reach the remote jungle location. After several hours aboard a slow train they had waited for a bus which, when the weather and roads were not too bad, could cover in a day the forty miles or so to a coastal village. On bad days, the bus didn't run at all. From the village a small boat carried them to and into the mouth of a river. After passage by water so far as possible—the boat passage also was dependent on favorable weather—they had tramped for ten hours through crocodile and serpent-infested jungle to find not a vein of ore, as they had expected, but a lone metallic lump which they judged to be of low-grade quality.

After this failure of hopes for a rich iron ore prospect, the sample had been given to the Bureau of Mines. Had we not visited Manila no doubt it would be lying there yet gathering dust, its identity perhaps lost for all time among the multitude of "no value" samples with which it shared storage space.

After I heard young Tanada's hard-luck story I asked if he and his partner would be willing to relinquish their filing rights. They would be glad to do so, they told me, and for a small fee would see that I was guided to the site. Mendoza had relatives who lived in Gumaco, much nearer to the location of the meteorite, and arrangements were made by telephone for a family member to guide me to the meteorite. Accordingly, I purchased camp clothes and equipment and we boarded train for Gumaco the next morning.

We arrived at Gumaco at 1 **P.M.** As I stepped from the train to help

Addie down, I crumpled with a badly turned ankle. Our host was most solicitous, installed us in cheerful quarters and provided a vessel and hot water for my injured foot.

Toward evening I felt so much better that we set out to shop for a needed pair of khaki trousers. There were four or five stores in the village; each handled just about everything from clothing to hardware. The purchase of a pair of trousers seemed an easy chore. But though each store carried khaki clothing, for the first time in my life I found myself inconvenienced, at five feet five inches, by being too large. It was only then that I noticed how small are the people of the Bondoc Peninsula. A pair of trousers was ordered to measure—and within two hours I was ready.

Now, however, a doctor called to examine me at our host's home ordered me to do no walking, thus ending the excursion. Sadly disappointed, we returned to Manila by train.

If the profession of meteorite hunting deals out some cruel blows it also springs marvelous surprises. Ten years earlier a visitor from Manila to our museum on Highway 66 had shown a keen interest in meteorites. He was John A. Lednicky, a University of Kansas graduate who had lived in Manila most of his life. After his return to the Islands he sent us three fine tektites and we continued to correspond. I had telephoned him while we were in Manila, and an invitation to dinner at his home awaited us on our return to that city. During the evening I told him about the sample that the Bureau of Mines had turned over to me, my plans for investigating it, and my disappointment. The report given me by Senor Tanada indicated a mass of a ton or more—perhaps several tons. I mentioned that I might make a return trip.

Mr. Lednicky said that if and when I needed any assistance he would be glad to help. He had access to all kinds of equipment and he liked such work.

In the following months, as we traveled in Vietnam, Thailand, Australia and New Zealand, and during our leisurely ship journey home, I pondered the Bondoc story from time to time: Everything pointed to an unusually large meteorite; there were indications that it was a new variety; and its geographical location was especially important, since it was only the third find in a land area that should have yielded several times that number.

I decided to write to John Lednicky to request the help he had offered. His reply was prompt: He had given the matter careful thought and would go to the site as soon as weather would permit, Bondoc being a narrow peninsula that suffers very severe monsoon rains and windstorms and is subject to typhoons. Lednicky added that while awaiting good weather he would look carefully into all of the legal aspects of the project.

I sent letters to Tanada and Mendoza introducing Lednicky as my representative. On September 15, 1959, Lednicky wrote again—he must wait until after the national election because bandits were operating on the peninsula; there had been considerable shooting. But after the election there followed more rains, more typhoons; then an illness kept Lednicky in the hospital for some time.

February 13, 1961, he reported that he had visited the site after great difficulty, having had to walk nine hours after following the crocodile-ridden river as far as navigable by boat. But he wrote that the stone looked like ordinary iron ore, although he could find no vein connected with it. On March 24, he wrote sad news. "The so-called Bondoc meteorite is just a hunk of low-grade hematite and not a meteorite at all." He had shown samples to his father, an experienced mining man who had prided himself on knowing meteorites, and to two geologists, who had just "laughed it off" as "some of that low-grade iron ore" that had been "coming out of the Bondoc peninsula for the past fifty years."

Now, I knew that Lednicky either must have reached the wrong rock or else this was a new type of meteorite. The sample submitted to the Bureau of Mines could not be mistaken for low-grade iron ore because it was *metallic,* bright, tough metal inside its surface rust. If it had come from the same rock as that which my friend had visited, then here was a stony meteorite which bore large lumps of metal. I managed to reach Lednicky by phone and asked him to send his specimens to me at once, air mail; I was sure they were meteoritic; this evidently was a new type of meteorite; I wanted it more than ever.

Lednicky had to await legal clearance before he could send the samples, but on June 25 they arrived. Tests proved them to be just as I had suspected—typical stony meteorite in which most of the small metallic grains had oxidized. I urged him to make every effort to recover this great meteorite—whatever the cost.

A reply from Lednicky dated July 6 expressed surprise that I still considered the specimen to be a meteorite, because among local geologists the belief was unanimous that such "ore" had been coming from the Bondoc since time immemorial. However, he was taking steps to have the mass removed and shipped to me.

On November 23, Lednicky wrote that the stone was much larger than had been estimated. The field crew thought now that it would weigh eight tons—such a size would necessitate the use of a large bulldozer at a cost of $100 a day; a crane at $250 a day, with the probable total cost, $10,000. He advised caution. I telephoned him that the measurements that his men had reported would mean far less weight than the estimated eight tons, that my specific gravity tests indicated not over 3,000 pounds; I asked him again to get it out at whatever cost was necessary.

As I learned later, his men reported on January 9, 1962, that they had been able to load the meteorite on a wooden sled, but that three carabaos had been unable to move it. Lednicky advised them to try a small bulldozer. When that was not sufficient he himself went down with a larger 'dozer and the meteorite was moved to the mouth of the river.

On February 21 Lednicky wrote me again. He had gone personally to the site for the third time. By making careful measurements he found the meteorite to be much smaller than his men had reported. Also, he had dug around and under the original resting place and recovered many small pieces. He found, as I had predicted, that these were not of the same specific gravity as the first metallic sample.

Now a raft was being built on which it was proposed to tow the meteorite to Manila. Recovery costs, Lednicky estimated, would not run over $3,700.

On May 29 he wrote again; the meteorite at last was in Manila:

> The last phase of the recovery was rather risky and gave us some worried moments. The day we got it on the bamboo raft for the trip down the river and across the stretch of sea, a typhoon showed up. The water got so turbulent that we had to hire two motorized fishing boats to stabilize the raft. Night came and one of the boats started to founder so we steered close to shore as I was afraid to lose about $3,000 worth of recovery gear that I had borrowed from the office —besides the meteor. As we got near the coast of Mulanay one boat sank and we almost lost four men trying to keep the raft from collapsing as the waves were unusually big. It was a nightmare all the way —so near and yet so far.
>
> Once it was ashore I found it hard to hire a truck for the run to Manila. All our office trucks happened to be out of town and none of the trucking firms in Manila wanted to rent us a truck either because they were advised that the roads were lousy or due to the uncertainty of the typhoon. Luckily, I ran into a friend who would let me use one of his large trucks provided I had it back within twenty-four hours. It was sent after the meteorite and everything seemed fine until the truck wasn't showing up when due to return.
>
> It gave me several anxious hours waiting as I worried that they got held up as they were lugging $2,000.00 with them to pay for the recovery team in the field. It finally showed up just before the deadline with the precious cargo. I was able to sleep soundly after that for a while.

John Lednicky put three and a half years of effort and frustration into the "favor" he had offered in late 1958. Without him the Bondoc meteorite never would have been recovered.

Even after the great meteorite finally reached Manila there were more delays and red tape before it could be carefully crated and shipped to the United States. It weighed 1,955 pounds—a shade under one ton and the second largest stony meteorite ever recovered. At the Flagstaff station, in August of 1962, a wrecker hoisted the massive stone onto a special, small trailer and we hauled it down Oak Creek Canyon to Sedona. It was installed just inside a window of my little studio off the main part of the house. Here I shared working quarters with it while I studied its exterior. Surprisingly, I found that it holds a complex system of magnetic fields—the first meteorite found with such magnetic properties. The Bondoc meteorite has magnetic poles, negative and positive miscellaneously, scattered every few inches over its surface.

Anxious to see the inner structure, I solicited the help of C. H. Brandmeyer, friend and neighbor, to build a reciprocating saw. Then I set to the task of cutting the meteorite. I estimated the time that would be required and Addie and I sent out invitations for the "opening." After 162 hours of saw time a twenty-eight-inch slab, weighing 120 pounds, was removed. The inside was as interesting as the outside, bearing large metallic inclusions such as are known to occur in only one other stony meteorite.

The end piece was carried as our gift back to the laboratory at Tempe by Carleton Moore, who was among the sixty guests at the Bondoc "opening party."

Across the world the real hero, John Lednicky, accepted only expenses and the satisfaction of success for the rather large fraction of his life's energies that Bondoc cost. As partial thanks I sent John a meteorite suitable for a wall decoration.

5

When I was in Mexico in 1929 a veteran geologist, Dr. Aguilera, told me of a meteorite he had seen in a yard in Loreto, Baja California Sur. Then, in about 1950, a Los Angeles engineer and oil man, John B. Quinn, wrote me a similar story: He was virtually sure a meteorite was lying in a man's yard in the village of Loreto; he had tilted it and estimated that it would weigh 150 pounds. There was little chance of my being able to go into Baja in the near future; the report was filed for future investigation.

In 1952 Addie and I decided we could rake together enough for a drive down to Guaymas on the Mexican mainland and from there I would fly across to Santa Rosalia in Baja California. Mr. Peter Mahieux, superintendent of the large copper mine there, a friend of Quinn, had offered to assist me in reaching Loreto. I boarded a cargo plane used by the mining company to commute across the gulf. Between Guaymas and Santa Rosalia the door to the cockpit opened and Mr. Mahieux, whom I had not met and who I had no idea was aboard the plane, came back and introduced himself. He had noticed my name among the dozen passengers listed. He told me that he had at his home a small meteorite which he would give to me.

Mr. Mahieux took me to his quarters in Santa Rosalia, filled with interesting relics from various parts of the world. He brought forth from his mineral cabinet a beautiful little meteorite of the pallasite variety, saying that it had been brought to him by a native from somewhere near the village of Ignacio. This little meteorite was an exceptionally fine example of a rare and beautiful type, and also it represented a large geographical area never before known to yield a meteorite of any kind.

The following day Mr. Mahieux drove me by truck some twenty miles south to where a young Mexican maintained a machine shop, explaining that this young fellow previously had been employed by his mining company to pilot the trans-gulf plane we had ridden from Guaymas, but they had been compelled to discharge him because of a very disturbing trick that he frequently played on passengers. He would take off with a group; then when he got out near the middle of the 100-mile-wide gulf he would topple over and pretend he had passed out, remaining "unconscious" until the passengers were all in near hysterics. He seemed to derive great fun from this performance; but, said Mahieux, after one passenger had suffered a stroke the firm simply fired him.

It was this man whom Mahieux would ask to fly me to Loreto. I must have shown that the prospect scared me; Mahieux hastened to inform me that the young man was "the best pilot" he ever knew.

"He built the plane you will fly in; made it out of the parts of various wrecked planes and automobile parts, and it's a better plane than a new one straight from the factory."

His words were only partially reassuring, but there was no other course, nor could I back out when my host was going to such lengths to accommodate me. So I said nothing and arrangements were completed for the flight.

A retired navy captain and a young geologist were the other two passengers. We flew down the coast. The weather was fine. Below us Concepcion Bay was so glass-smooth and clear that I could see schools of fish in the water beneath us. We made a perfect landing in Loreto.

I called upon the padre at the venerable old church. He could speak some English and he guided me to one of Mahieux' former employes who also spoke fair English and by whom I then was escorted to the house of Sefior Davis, in whose yard lay the meteorite I had come so far to see. It *was* a true meteorite, and instead of being only half or a third as large as I had been told, it was even larger than Mr. Quinn had estimated. Instead of 150 pounds it weighed 209. A price was agreed upon and arrangements made for shipping it home.

I returned to the flying field, where my two co-passengers were ready for the return flight. But where was our pilot? He had been seen in a bar about an hour ago.

"Oh, my god!" exclaimed the captain.

"That S.O.B.!" cried the geologist.

Our pilot was found. He seemed to be in fair shape. We took him to lunch at once and saw that he drank only coffee, then went promptly to the plane. He took off without a hitch and when we had reached his cruising altitude he reached for his tobacco and cigaret papers and with a word or two and several motions directed the geologist (whom I shall call "G.") to take the wheel. Mr. G. protested that he knew nothing of steering, whereupon the pilot simple shifted the wheel over to him and applied himself to the rolling of his smoke. Mr. G., the back of his neck appearing as red as a beet to us behind him, refused to touch the wheel. The navy captain and I nudged each other and braced ourselves—to what purpose I don't know—and the plane began to bank and turn. The pilot reached over, righted it, then by insistent gestures instructed Mr. G. to look after it while he, the pilot, relaxed and slouched back for a rest.

Never have I wanted so strongly to hit a man over the head in all my life; but as I said to the captain beside me, just what good could that do? None of the three of us ever had received a flying lesson. The landing field in Santa Rosalia was a short one, ending at the very edge of a vertical cliff below which was the ocean.

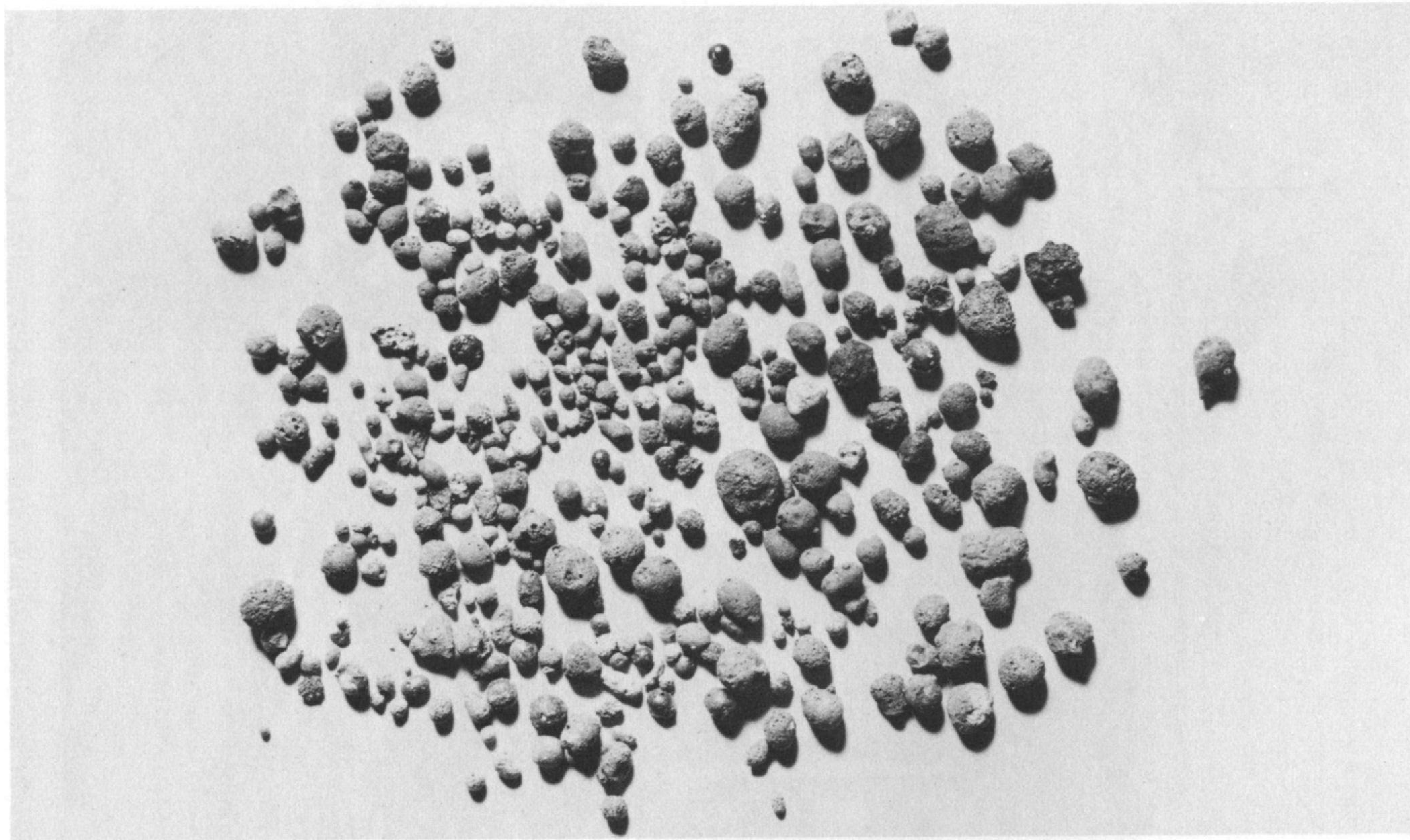
Finally, G. took hold of the wheel, but when the plane wavered he only protested again, for he didn't know what else to do. Meanwhile our pilot leaned back and enjoyed his cigaret, occasionally reaching over to right the plane. It was only a thirty- or forty-minute ride—but during it, his three passengers lived just about that many days.

When the landing field came into view our pilot took the wheel and made a perfect landing, but none of us felt inclined to overwhelm him with thanks.

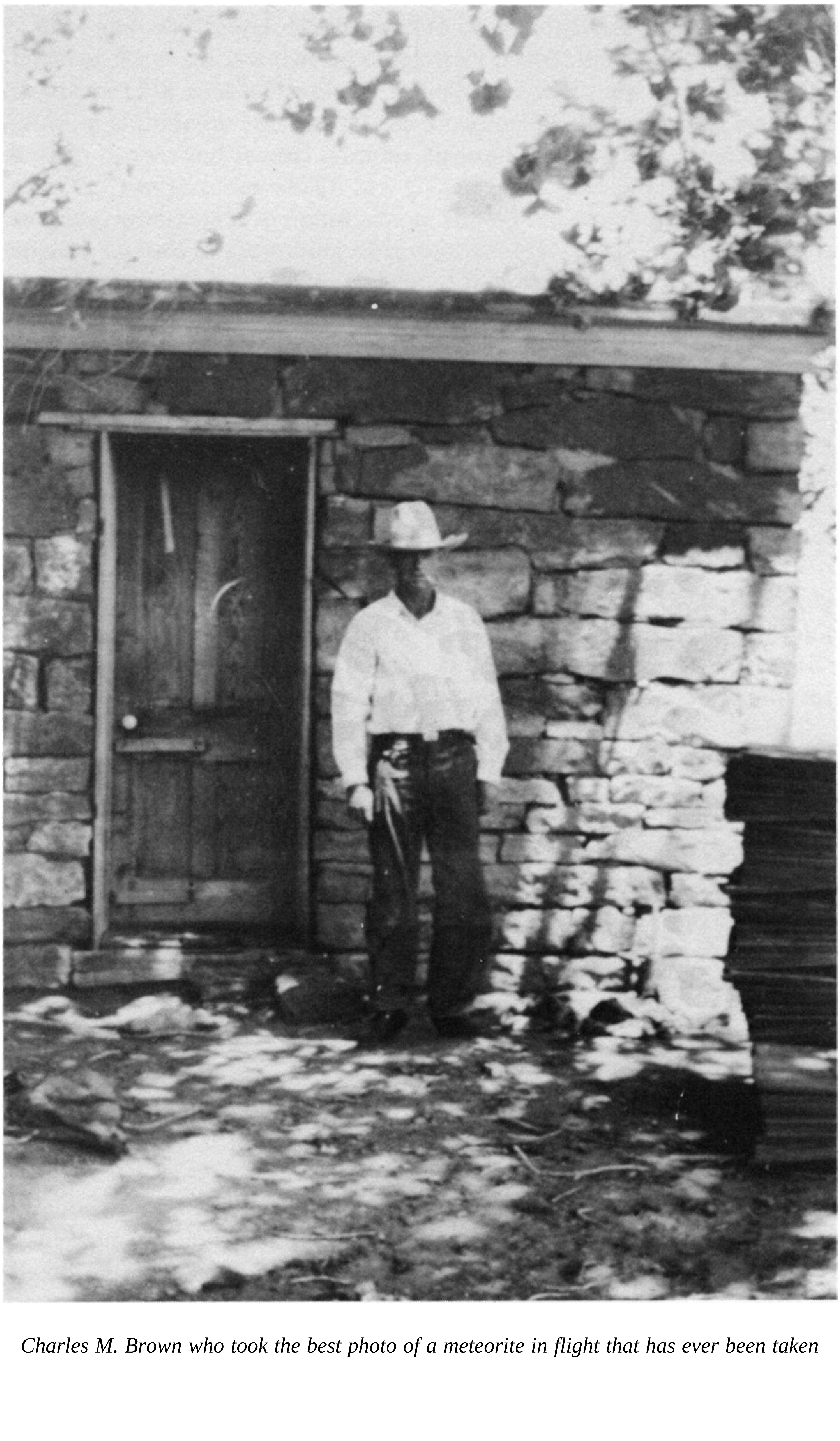
Senor Alexandro Davis, from whom I purchased the Loreto meteorite, related to me that his late father had told the family the meteorite came from a site in the mountains about six hours' ride by mule from the nearest ranch on the gulf shore, Luegi. He also had told the family that a much larger iron lay very near the one he brought down, but that he was unable to move it. I could not learn of anyone then living who knew the exact location.

The 209-pound iron I had bought bore on one side an area that showed plainly it had been torn from a larger mass; this break appeared to have occurred either at the time of impact or very shortly before. Thus the meteorite itself seemed to bear witness to the truth of the old man's story of another iron left in the hills.

In January 1964, and again in January 1965, we made the long trip to Baja California in search of the larger part of the Loreto meteorite. We were not successful, but there is nothing unusual about that in meteorite hunting. One day, perhaps, the second—perhaps even a third—Loreto meteorite will be uncovered by man or erosion, if the stories are more than legend, and will be brought to civilized view.



*Impactite, discovered by H. H. Nininger before leaving 1946–53 location.*



*Charles M. Brown who took the best photo of a meteorite in flight that has ever been taken*

6

In the spring of 1965 Addie and I traded in our Scout for a camper mounted on a pickup truck and spent the three summer months touring Canada and Alaska. On our way north we heard reports of a great evening meteor seen by many persons in British Columbia, Alberta, the Yukon and the State of Washington the late evening of March 31, 1965.

Scientists of the Dominion Astrophysical Observatory near Penticton, B.C., the University of Alberta at Edmonton and the University of British Columbia at Vancouver were impressed with the magnitude of the phenomenon and promptly collaborated in energetic efforts to locate the fall. On the basis of interviews with witnesses they established by triangulation the approximate terminal point of the fireball.

The radio stations of British Columbia and adjoining provinces and states, moments after the fireball, had been besieged by calls from their listeners saying the fiery object had come to earth in their respective communities. There were reports of violent repercussions over a great area.

Calculations by an eminent physicist on the basis of seismic disturbances of different magnitudes and at different distances from the terminal point led him to an inescapable conclusion that the mass of the meteorite responsible for the fireball must have been of the order of a million tons. This conclusion was considered proof positive that the meteorite must have produced a sizable crater, and a prompt aerial search was inaugurated by plane to be followed by helicopter.

The investigators at Penticton told me they had no very encouraging results of their two months of effort, but they had not given up. On the very day of our visit, June 6, the aerial reconnaisance of the rugged wilderness area still was being carried on. The cooperating scientists had gathered what seemed to be a very satisfactory lot of data; they had determined with apparent accuracy that the fireball had approached from a westerly direction and had disappeared at a lower than normal altitude over a remote, uninhabited and rather rugged terrain in southeastern British Columbia.

Patches of "black snow" were reported in a region in harmony with this determination. Requests for samples of the "black snow" brought a container of black mud to the observatory. This material was regarded skeptically and was forwarded to Ottawa for analysis. The reports returned indicated the presence of nickel but were far from positive.

I inquired if I might see a sample of the "black snow mud." All but a very small remnant had been sent to Ottawa, but they were glad to show me, somewhat apologetically, what remained. The sample was wrapped in white paper and stuffed into a glass jar. The rather crumpled paper showed smears of what appeared to be finger smudges from the black mud. In the folds were a few small, black, solid bits of matter, one of which was placed under a compound microscope for my examination.

When I brought the particle into focus I could scarcely refrain from shouting with excitement. I was looking at as beautiful an example of fusion crust as I had ever seen, and it exactly resembled the crust that I had examined on several type I carbonaceous chondrites, a type of stony meteorite rich in nickel-iron and distinguished by little rounded bodies called chondrules. Nearby, as a portion of one of the black finger marks, I could discern a small chondrule, perhaps .2 millimeter in diameter.

After expressing my conviction that they had a carbonaceous chondrite to deal with and that any search for a crater would almost certainly be futile, I was told that none of the group had visited the site where the black snow was collected, either while the good snow cover of March 31 still lay on the ground or after it had gone.

Evidently none of the men concerned with this survey was sufficiently familiar with the various types of meteorites to recognize the spoonful of "mud" as the product of disintegrated carbonaceous chondritic material.

On being unexpectedly faced with the overwhelming confusion of reports from excited and terrified witnesses, the men to whose lot it fell to deal with this very outstanding event had thought first of that feature which has been the central theme of ninety per cent of meteoritic literature —the great Arizona crater. Actually, such a disorder of reports suggests first the smash-up of a stony mass of uncertain magnitude and the showering of several square miles with large and small fragments and more miles with sand, gravel and dust.

The great good fortune of this situation should have been the snow cover on the terrain at the time of fall and the reports received of the black snow. There should have been no time lost in reaching the area by helicopter and snow shoes. From the site of the blackened snow the party should have radiated in a search for small disturbances in the snow: not a crater, but for small bits of black rock or masses of the deliquesced remains of such.

A brief laboratory examination of the mud that had been black snow should have told the investigators at once that the chances were a hundred to one that no mass larger than a few pounds should be expected to have survived, and that most of the material would be in the form of particles too small to cause any noticeable disturbance of the snow cover. From such a large mass there would be expected thousands of small, fully encrusted individual meteorites ranging in size from BB shot to a few ounces, with perhaps a few weighing several pounds, besides tons of dust spread over several square miles. The only evidence of such a deposit that could have been seen by plane was, of course, the black snow where heavy concentrations of dust had fallen. Masses of a few pounds would in most cases have been crushed as they struck the frozen ground beneath the snow and would not have rebounded as did stones of the firm-textured Bruderheim fall in the same province five years before.

The essential ingredient was swift action. The snow cover might hold small fragments briefly, or show the pockmarks of their fall; but as the sun's rays reached them they would sink from sight faster than the surrounding snow due to their capacity for heat absorption; by the time of snow melt a few weeks later they might have been badly disintegrated and in any case would present a formidably difficult target for search.

It was at a point somewhere between advanced technology and laboratory methodology that the investigation had bogged down: Lack of familiarity with meteorites lost for these highly trained and able men what probably was the most important meteorite fall of a century in North America. Carbonaceous meteorites are exceedingly fragile, and the evidence from field work is that the great bulk of such falls is reduced to dust long before they reach the ground. Therefore, they are rare, at least in collections; the actual frequency of their occurrence is one of the unknowns which it has been hoped that modern and thorough approach to fireball recovery will validate.

Carbonaceous meteorites of type I tend to alter rapidly. In a matter of two or three days, if subjected to moisture, they may simply change from a more or less firm stone to a mass of muddy consistency. Such alteration, of course, must mean chemical changes as well. Apparently, in the wilds of British Columbia, there had been delivered to the soil of our planet a large mass of the most sought-after variety of meteorite which now may have to be recorded as a mere inconsequential trace.

*Nor think I that God's world will fall apart Because we tear a parchment more or less. Truth is eternal, but her effluence,*
*With endless change, is fitted to the hour;*
*Her mirror is turned forward to reflect*
*The Promise of the future, not the past.*
*—-James Russell Lowell,*
*"A Glance Behind the Curtain."*

# 14. NEW PATHS AND BYWAYS

Man is not yet ready to write a chemical formula for the word meteorite. Twice within a half century crater-forming meteorites have punctured the land surface of the earth. Within the same period mountain-size asteroids have encroached upon the orbital precincts of our planet no less than five times—in one case with what might be described as a lucky near miss. Looking then at the pock-marked face of the moon, one concludes that meteorite impacts constitute a geological problem of considerable magnitude. Furthermore, we cannot expect that meteorites collected so far represent all of the varieties that fall to earth.

Some varieties have been encountered only once, others twice or three times, and some quite frequently. It is only reasonable to suppose that some varieties arrive on earth only once in a thousand years or perhaps in 10,000 years.

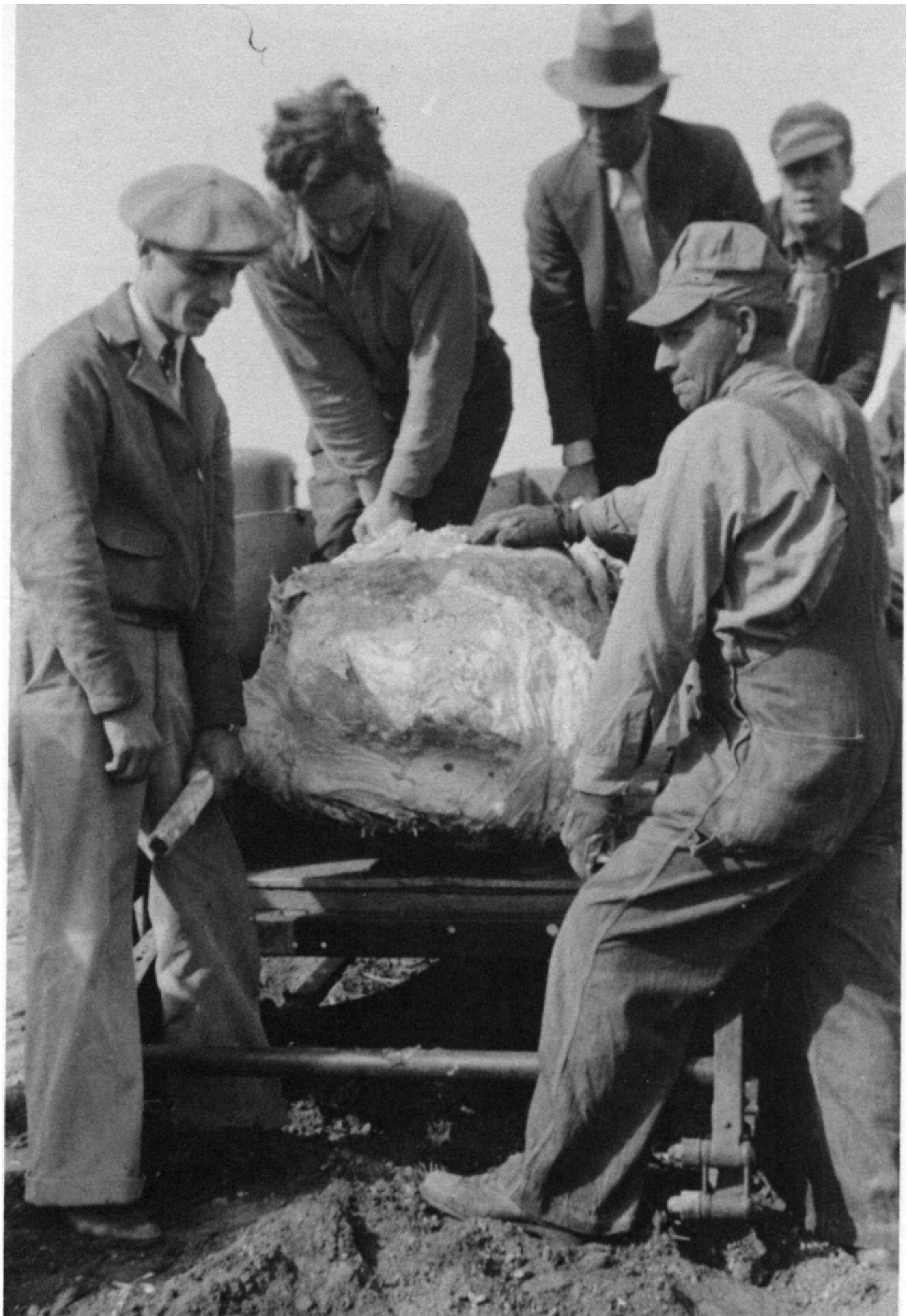
Among the more than 1,800 falls that have been cataloged, some varieties are represented by one, two or three falls. Such rare forms probably have arrived oftener than our records show; it is equally reasonable to conjecture that there are other varieties orbiting our sun, examples of which have not reached our planet since scientists began recognizing meteorites. Beyond the problem of varieties which may go unrecognized is the uncertainty regarding the existence or prevalence of combustible, icy or otherwise perishable varieties of meteorites in space.

We do not yet have an adequate sample of the over-all increment of meteoritical matter. Until we do, all of the efforts at analysis and measurement of the eatth's cosmic relationships are not very meaningful.

One of the fascinations which meteorites hold for man is that man simply can't know, by his present knowlege, when or what to expect in the way of a fall of great size or new variety.

The ancient civilizations of Europe and Asia, through superstition or out of curiosity, disposed of nearly all the meteorites with which they came in contact long before their meteoritic origin was understood. On the

*Dr. Nininger's son, Bob, listening for the "bark" of a buried meteorite thru a magnetic balance.*



*Mr. Lynch and helpers loading Hugoton find into trailer.*

North American continent, where civilization is relatively young, man has had access to the accumulated increment of many thousands of years, most of the survivors being the more hardy irons.

In the century and a half since existence of meteorites has been recognized, man has recorded an average of about three to four falls a year from which specimens have been recovered.

As I first began to peruse the literature on meteorites in the 1930's I was impressed with several dominant inconsistencies: The matter of the number of meteorites that reach the earth; the discrepancy between the number of irons recovered and stones found, and the assumption that nearly all stony meteorites were *chondrites,* a type rather rich in nickel-iron and carrying as a prominent constituent little rounded bodies known as *chondrules.*

It seemed that quantitatively meteorites were considered to have no meaning. I asked the late Dr. F. R. Moulton why this attitude existed, telling him I had evidence that far more meteorites were falling on our earth than was consistent with the extant literature on the subject. Dr. Moulton replied that the question would be worth investigation if I could demonstrate that the meteoritic increment was several thousand times as great as had been assumed. He indicated that he was sure this could never be achieved.

Although actually I believed it to be true, I did not have enough evidence at that time. Dr. Moulton died December 7, 1952. Had he lived ten years longer, perhaps I could have convinced him.

I was amazed to find that the mass of material represented by each of the recorded falls seemed to have been considered as approximately equal to the amount recovered.

An illustration of the magnitude of this error is the Plainview fall. My first experience with this great shower came by way of a Mr. Rightmire, who informed me that he had two meteorites he would like to sell. He said that Dr. Merrill had told him he had all he needed from that fall. Naturally Merrill's response to the farmer in this case simply put an end to the search for stones. I chanced to learn later that at the very time Rightmire offered him those two stones some of the neighbors had been throwing meteorites out of the fields into fence rows and into the water holes of the neighborhood. Merrill described Plainview as a fall of total weight of 68.2 pounds; ultimately, known stones totaled some 1,500 pounds.

As early as 1933, in *Our Stone-Pelted Planet,* I began to dispute the estimates of the amount of increment to the earth.

At the rate of infall estimated by one respected writer it would take fifty billion years for a layer one foot thick to accumulate on the sea bottoms.

Since man occupies only a very small part of the planet, and since experience shows that only in a very small portion of cases were falls discovered even though they were in civilized areas, it is evident that the number of known falls is a small percentage of the number that actually have landed on the earth. Work in the field led me to conclude that perhaps several thousand falls occur upon the planet each year, the majority of which of course land in the great seas, wide expanses of arctic snows, jungles, deserts and other areas where man is not present to observe. In the course of a thousand years there is an enormous amount of meteoritic matter sprinkled about our earth. Some of these meteorites are of such nature that they would last for many milleniums before complete disintegration. Others would survive a few years. A few would become nearly unrecognizable in a matter of a few days, or in wet weather might be reduced to mud in a few hours, but the majority of meteorites are of such character as to survive the action of the elements for at least a century.* It is not surprising that during this century and a half of man's recognition of meteorites there have been comparatively few specimens found that were not seen actually to have come to earth.

I believed that inadequate field work in cases of witnessed falls left important small constitutents of those falls uncollected, and also that the meteoritic dust and gravel carried in the cloud trails actually constituted the principal bulk of such falls. Setting out by field work to gather facts to replace assumptions, I came up with an estimate of meteoritic increment of 50,000 tons a day, which would amount to a layer nineteen feet thick in 60 million years. It is yet too early to say how nearly my estimate was justified; but every year the "experts" come nearer.

My field work proved, as I had contended would be proved, that long-accepted theories as to the ratios of occurrence between metallic and stony, and between chondritic and non-chondritic specimens, were false because they were made without the existence of any meaningful or extensive field program on which to base conclusions.

I reasoned that there are unbelievable numbers of meteorites remaining unfound because people are unable to identify them as meteorites. Iron meteorites differed most from terrestrial rocks; chondrites differed more than did achondritic stones. Our work demonstrated definitely that stony meteorites are some hundreds of times as abundant in the soil as had been supposed, and that the ratio between them and metal meteorites was not different among unwitnessed falls than in witnessed falls. In the course of chasing down as many fireballs as possible, half of all the finds made proved to be of the achondritic class.

In an area of 450,000 square miles we recovered representatives from 200 previously unknown falls of stony meteorites in thirty-five years; yet probably not more than ten per cent of the population of the area ever was contacted by our group either by word of mouth or by printed matter.

***Here I refer to the well known kinds of meteorites.**

My program of instruction through the schools, lecturing and field activities was initiated in 1923, and by 1950 the State of Kansas, that yielded only fifteen falls in a period of seventy-five years, had given us representatives of 40 additional falls.

The large number of meteorites found in Kansas can be attributed to two factors—the land's relative freedom from rocks and the "interest factor"—the acquaintance of the people with meteorites.

It was our experience that when a barren area was properly investigated it no longer was barren but might turn out to be a most productive area.

In the Texas Panhandle only one meteorite had been recorded previous to 1933; in that area twenty different falls were recovered during the next seventeen years. At the same time the area around Plainview, adjacent to the Panhandle on the south, where we really concentrated our search, yielded a dozen more falls.

It is impossible to separate the influence of the museum from our earlier field work, the lecturing in schools, writing for small town newspapers and other ways and means of attracting the public's attention to meteorites. It is certain that our whole educational effort did much to arouse an active interest in meteorites among scientists. Many of the papers that reach my desk from all over the world seem to reflect discussions held over our museum cases or at the crater. I kept no record of such discussions; there were hundreds of them. Many ideas that were presented and discussed have become widely accepted since.

Our museum and our activities provided a forum and a kind of experimental laboratory for ideas. But besides exerting indirect influences our program directly accomplished and proved certain facts and erased several erroneous notions that had been held by scientists for many, many years. Most of these findings were the outgrowth of our field work, by which our very small force of workers brought to light more meteorites than were being recorded by all institutions of the United States and of the entire world.

Showers of stony meteorites previously were considered to be the exception; we proved them to be the rule.

We brought to light at least 222 previously unknown falls, aggregating more than 2,000 individual meteorites. A number of additional falls probably came to light as a result of this effort and the publicity which resulted, but were not traced to us as the original alerting agency.

In the year 1937 thirty-one new discoveries were tabulated within a twelve-month period. This one year's harvest was a larger number of meteorite discoveries than ever had been recorded in any three-year period for the entire world. In his book, *Between the Planets,* published in 1941, Dr. Fletcher Watson of Harvard wrote that "At present Nininger is accounting for half of all the discoveries in the world."

We examined some forty-odd pseudo-meteorite craters that we proved to have been formed by causes other than impact.

I published more than 150 papers, four books and two booklets, and distributed at least 200,000 free leaflets.

We were sent some 35,000 specimens thought to be meteorites. These were examined and free reports provided to the senders.

A revered elderly astronomer once criticized my work by saying that I had not added greatly to meteoritical theory. My reply was that I had spent my time gathering facts, and the more facts I gathered the less certain I was that we were yet ready for more theories.

I have been asked about programs to be followed in studies of meteorites in the seventies, as we begin to edge our way farther into space beyond the moon. In reply I mention first the suggestions I have been making for a generation. Some would continue precisely the activities we pursued over the years and that remain unfinished. Others we never were able to undertake adequately, and there are yet others that could not be foreseen until space and the atom were tamed.

It is important to obtain useful quantitative data:

(1) Through recovery of fireballs and recognizable meteorites;

(2) By applying new technics and intensified effort to the matter of terrestrialization, to discover reliable clues by which to identify even the completely altered remains of ancient meteorites;

(3) By study of all of the grist from the friction mill of the atmosphere —the ash from millions per hour of "shooting stars"; ablated particles from surviving meteorites; terminal dust clouds and showers of sand and gravel discharged from stratospheric smashups, including particularly the *non-magnetic* portions.

We must inquire further into the nature of crater-forming falls, the forces and effects attendant upon the instantaneous displacement of hundreds of millions of tons of rock by impact and the products of explosion and impact. Further investigation should be made of the effects on meteorites of cosmic rays, an aspect attracting probably more researches than any other single question relating to these travelers from space.

There has been to date little progress in the introduction of instruction on meteorites into the curricula of elementary and secondary schools and colleges, which I have urged for many, many years as an essential to truly substantial recovery of meteoritic materials.

2

Meteorites are in a class by themselves. All other material belongs to this earth and so far as we know has been on the planet through all geologic time, but meteorites are invaders from without. They represent other parts of the universe about which we as yet have no way of learning save as we study the light that arrives from luminous sources, and as we begin to catalog and interpret photographs taken by the satellites that are the new miracles of our age. The lumps of stone and iron still are our most tangible source of information concerning the vastnesses of space stretching immeasurably in all directions.

A small boy asked me, "When do meteors become meteorites?" Rather than to consider whether the change takes place in burning flight, or at the instant that destructive friction ceases, or on striking the ground, it seemed simple and plausible to explain that an object is a ***meteorite*** invisible in space until it flares up during its struggle with the atmosphere, producing a light that is known as a ***meteor,*** and that what remains to reach the ground is still a ***meteorite.***

Friction has reduced its size, and has changed its surface texture and contour, but for the most part the materials in the stone are not different from what they were in space.

Our solar system holds a great expansive multitude of meteorites with the sun as their central controlling force around which each member revolves in an orbit. The number of meteorites in this great aggregation is too great to estimate in the present limited state of man's knowledge, but astronomers tell us that in the course of a year our own planet in making its annual journey around the sun is bumped into by more than eight billion meteorites, each of which is large enough to produce a "shooting star" or visible meteor, and that a thousand times as many more plunge into our atmosphere which are too small to produce visible meteors. This would give us a figure of eight million million each year that are swept up by our own little planet.

Although we have pushed out the horizons of knowledge a long way since the time when the earth was considered the central feature of the universe, we really have only very superficial knowledge even of our own insignificant planet, this speck of the solar system we call our world.

If a huge map the size of an ordinary city block were made of the known universe, the earth could not be represented at all. An ordinary punctuation mark, a period such as is used on this page, would be more than fifty thousand times too large to represent even the outermost limits of our solar system.

Scientific investigations of our earth have been limited to a very thin outside layer. Using a large apple to depict our planet, cutting it crosswise between the blossom and stem end, the skin would represent a layer about twenty-five miles thick on the outside of the earth. Most of our first-hand knowledge is limited to a depth of only about a mile, although in a few places the earth exposes its own interior to a depth of a few miles. Our mines dip only a little more than two miles into the earth, and these penetrations occur only in scattered places. Even the planned Mohole project would reach only to a depth comparable to one fourth of the thickness of the apple skin.

We know very little aside from what we can see on the surface of the earth. Going upward we have until very recently been limited to the stratosphere, and our space explorations have as yet been confined to a few vehicles, a few men, for small spaces of time and circumscribed areas in space, and under such restricted conditions as to afford only limited information.

Until we receive more and better information about the moon and the planets and boundless space, we are limited to an extremely thin film on the exterior of one planet of one of the smaller systems of the universe. As we try in every way possible to find out more about this vast enormity of space we live in, certainly we owe interest to the stones that come to us from the mysterious reaches of space.

The subject of meteorites so long was relegated to the ranks of least important, so little attention paid to it that even now there are States among our Union that have provided not a single meteorite discovery, yet hundreds of meteorites are mingled with the soil of the smallest state.

"Weigh yourself daily," say the scales at the corner drugstore. Our doctors echo the admonishment.

"Check your waistline every million years," we say to our planet.

Only as the half-way mark of the twentieth century was reached did science begin an intensive diagnosis of the effects of wanderers from space on the state of the earth.

The most annoying occurrences of my museum days were those occasions when some visiting scientist would peruse the collection and then murmur, "Interesting, but of what use are these meteorites?"

As the space age dawned, scientists at leading research centers began to purchase bits of meteorites for analysis. These growing orders for research material more than once staved off impending decisions to give up the museum and the program.

The Dominion of Canada is supporting a project of exploration for and into craters and other impact scars of ancient vintage—"fossil scars" dating back half a billion years. The U.S. Geological Survey has established a Laboratory of Astrogeology. The Astrophysical Observatory of the Smithsonian Institution now has a nation-wide program of meteoritical research under way, including the Prairie Network of photographic batteries for tracing incoming meteorites that is the very reality of the dream I advanced in the middle thirties.

In the United States there now are scores of young astronomers and geologists, geophysicists, geochemists and mathematicians devoting their talents to the problems of extra-terrestrial forces acting upon our planet. Many of their researches are directed to refined chemical studies of various kinds, formulation mathematically of hypotheses which explain the effects on our earth of great meteoritic impacts, and to nuclear means of measuring ages of meteorites in space and so contributing to understanding of the origins of our solar system.

Naturally, I did not foresee the extensive possibilities that have developed since the tool of atomic fission has come into such general use. But I did point out, as early as 1934, that there must be some relationship between cosmic rays and the meteorites which are immersed in them during their long sojourn in space.

Meteoritics truly is on the march. Many young men now are engaged in astronomical, geological, nuclear chemical studies and isotopic analyses that were not thought of nor possible a decade or two ago.

In the complex world of the seventies these young researchers make great contributions, yet most of them, by the nature of our changed world, are confined to in-depth studies in a few critical but specialized areas. Their brilliant minds are exceedingly well trained, and their contributions are great, but I would not wish to trade the opportunity I had to explore a broad and relatively untouched field in years when one had time and opportunity to make his own path and to take time to look at whatever he chose along the way.

The new researchers are yielding extremely valuable information regarding the evolution of our solar system and the greater universe. Underlying all of the specialized investigations should be an equally vigorous campaign for the recovery of material for these men to work on.

Some geologists have come to realize that our planet bears proof of having been bombarded by large as well as small chunks of matter and are beginning to look for evidence that such bombardment has had its effect on the processes of mountain building. Eventually the geologists will change their views and their textbooks in the manner of the astronomers, whose acceptance that the moon's face bears scars of impact rather than volcanism forced on their brother scientists a search for evidence of a similar bombardment of the earth.

I have the satisfaction of having been a member of a rather small group who marked a turn in the road that science must inevitably follow. The space program has revealed that Mars, like the moon, is pockmarked with meteorite craters. Eventually, methods will be developed to determine definitely that the earth, whose surface continually is subjected to the scrub brush of erosion, has been similarly bombarded by giant missiles during hundreds of millions of years. It must follow that millions upon millions of small masses have arrived and have been terrestrialized beyond recognition. ': ^fttftj

The earth's atmosphere constitutes a very effective armor against small meteorites, but not against large ones. For example, a meteorite one foot in diameter would be virtually stopped by the atmosphere and would strike the ground at a few hundred feet per second. One ten feet in diameter would weigh one thousand times as much, but it would have only one hundred times as much surface for the atmosphere to press against and thereby check its speed. For a mass a mile in diameter there would be almost no reduction of speed.

Every now and then for more than a generation, an introduction to an audience has described me as "the man who has discovered more meteorites than any other man who has ever lived." The record is one of which I am rather proud, but in my opinion it is not my chief contribution to the young science of meteoritics. I would rather believe that the finding of meteorites only served as a means to the more important end of helping man to better understand the environment in which he finds himself; I would like to think that my interest in these immigrants from space reached a little farther than the number of meteorites resting on museum shelves.

Specimens like Estherville and Bruno bring messages written on their stone or iron faces, and chemical and nuclear tests tell us more about their composition and their origin, yet interpretation of this information is difficult enough, and the facts bared by each specimen are so comparatively few, that we need to recover every meteorite, and every kind of meteorite that it is possible to recover, so that as each specimen adds to our fund of knowledge and each helps to make some one point clear, we are able from the aggregate to understand some of the mysteries of space beyond our planet and of developments previous to the records of history and pre-history as we now have them.

Perhaps my greatest contribution to meteoritics has been the creation of proper interest in the subject, and the suggestion of lines of investigation which, though at the time considered out of bounds, since have become worthy topics of discussion and study.

Dr. Gerard Kuiper, in about 1955 or 1956, invited me to contribute a chapter for Volume Four of the series on the solar system that he was editing: *The Moon, Meteorites and Comets.* When the 800-page volume was published by the University of Chicago Press in 1963 it included a dozen chapters on meteoritics, and Dr. Kuiper and his co-editor, Barbara M. Middlehurst, referred in the preface to "the almost explosive growth of this subject in recent years." Several of these chapters concern aspects in which I attempted to arouse interest back in the thirties and forties when publishers regarded them as too far out for print; thus many ideas which I advocated without much research to back them up came to be respectable topics for expert treatment.

A few years ago a long distance telephone call came from a researcher in Harvard University. He inquired about a statement I had made some three years earlier to the effect that a certain meteorite was a fragment and not a complete individual iron from space. I explained that my conclusion was based on what I had learned from studies over the years of the surface features of many meteorites, including the one in question. My caller then told me that nuclear studies of this specimen indicated I was correct, "But I wanted to know how you knew."

What I had learned about meteorites I had learned from observation, and from applying as well as I could all the facts that I observed. For more than forty years I directed most of my time and thought to one subject, one overwhelming interest—meteorites. It should not be surprising that some knowledge and new ideas resulted from such single-minded attention.

The recognition and occasional plaudits now are gratifying, but it is somehow ironic that it took a Sputnik and the sale of my life's collection "to seal my verdict that meteorites *are* important.

In March, 1965, Carleton Moore brought two scientists from the Ames Laboratory at Moffett Field to discuss meteoritical problems and to take with them some of the enigmatical specimens that we had been *accumulating during forty years,* to learn if a newly developed instrument for detecting ancient exposures to cosmic rays might render definite conclusions as to whether or not these specimens are of meteoritic origin.

Ours is the age of mathematicians. Stimulated by the great discoveries of Einstein, men have sought to use mathematics almost to the exclusion of other equally important scientific methods, particularly the ways of observation. With the invention of the microscope the biologists concentrated on ever smaller and smaller units, often to the neglect of the organism as a whole. With the perfecting of more and more powerful telescopes the problems of deep space absorbed the attention of astronomers to the exclusion of work on members of our own solar system.

The old saying that one may become so concerned with the individual trees he fails to see the forest illustrates quite well the behavior of man before the advent of the telescope. If the saying is reversed it applies equally well today, when constant advances in the power and efficiency of instruments with which to explore ever greater and greater reaches of space have led men to neglect some of the aspects of our surroundings that are nearby, but, like the trees, are essential to the forest.

By their very nature many meteoritical problems must be solved by a combination of field work, laboratory tests and mathematical analyses. There has been considerable printer's ink wasted in efforts to explain why meteorites are absent from all but the most recent geological formations. Much greater quantities of ink have been used to demonstrate by mathematical analyses that the meteorite did or did not explode to produce the great Arizona crater. The over-all image of meteorite composition was for a century calculated on the assumption that collections in museums constituted an adequate sampling of the total increment of meteoritic material.

Portions of the beautiful pallasite of Springwater, Saskatchewan, now shine forth in various collections of the world only because a farmer was a better observer than was the provincial assayer who, as a student, never had been shown a sample of pallasite meteorite, and so judged the farmer's specimen to be merely leakage from a furnace. Because of the farmer's acuity and refusal to accept this mistaken judgment, the world acquired a specimen that bears a mineral hitherto unknown either from the earth or sky, discovered in 1960 and christened *Farringtonite* by E. R. DuFresne and S. K. Roy in the course of modern-day investigations into the nature of specimens gathered and preserved against the day when the meanings they hold for us should become clear.

The Canyon Diablo irons first were described in the early nineties by men who observed, and who decided rightly that the surfaces of all of these irons were weather surfaces, that any fusion crust they ever bore had long since flaked off due to oxidation. In my personal examination of many thousands of the irons I have yet to see the least bit of fusion crust. Probably they were well covered by such crust when they fell 20,000 to 50,000 years ago, but even weather-resistant nickel-iron suffers from oxidation in that length of time. Yet there are men today who think that on those irons is still to be found the original fusion crust. These are men who never have developed powers of observation. They accepted without qualification the statement that fusion crust is a typical feature of meteorites, and so, rather than recognizing the ability of nature to obliterate natural features, they identify as fusion crust the brown film of oxidation that has replaced the original fused surface during Canyon Diablo's centuries of weathering.

It has not been many months since I was showing an eminent astronomer some small meteorites I had brought home from a recent field trip. He spoke of them as being nickel-iron and, when corrected, responded, "Well, *most* meteorites are nickel-iron, aren't they?" They are not.

Scientists from all parts of the United States and from many other countries walked about the Arizona crater environs over the years, seeing the big hole, viewing specimens of meteorites, reading past accounts of the crater's making. They walked, without knowing it over impactite bomblets by the millions and over more millions of metallic spheroids—the two most meaningful classes of material found in tremendous quantities in the vicinity of the great crater—for they did not observe that of which they had not read. Nor did I for many years.

I have now lived long enough to be able to look at my early life somewhat objectively and from this vantage point I realize, commendable or otherwise certain characteristics have dominated my behavior. Nothing could have turned me from my chosen field of action. Stubborn? One of my friends put it more kindly. "You are one of the last rugged individualists," he told me.

There has been a tendency to try my hand at doing something someone said couldn't be done, and a tendency to question everything. These characteristics have affected my life all the way through; sometimes as afflictions, sometimes to advantage.

Men had studied meteorites many years before my time, but only as a special diversion from the professions of mineralogy, chemistry or astronomy. The best of them tried to convince me that the subject was not worthy of a professional attack.

Mine was a strange, unique and to many of my contemporaries, a mysterious career, without precedent, without salary, without capital. There were no blazed trails to follow; there were no subsidies and no institution willing to be associated with such an unorthodox approach to a relatively unpopular scientific discipline. The same goal was pursued steadily, sometimes painfully, through four decades. There were times when the financial fog got pretty thick, nearly obliterating the road ahead.

Probably my "unique" career will have to remain unique. I was in the fortunate position of living in a time when it was possible for a man to make his way through some unusual pursuit; and I was privileged with the opportunity of studying all phases of meteorites, the means of their recovery, what they had meant to our earth, what they are made of, what tortuous descents through the atmosphere they had survived. In today's technological world scientists are much more restricted to areas or kinds of researches, and most will not experience the fun of the whole view, as I had it.

I insisted to myself that when the importance of my program became known, finances would be available for its completion. This has come to pass in time for me to be witness to it, but not in time for me to play a key part as I had hoped.

Each individual who spends his lifetime in natural science becomes wrapped up in that phase which claims his attention. There are no dull days for the man who devotes his eyes and mind to the lives of wild animals, fishes, reptiles, birds. His life is one continuous series of surprises as he finds and investigates new forms and uncovers new behaviors and characteristics.

Our new world brings more leisure; the natural sciences stand to play an important part in the occupation of that free time and in making it useful as well as enjoyable.

The field of fossils carries us back into the realm of infinite time; astronomy carries us out into a speculative pursuit of infinite space; but meteorites are concrete messengers out of both infinite time and infinite space.

Fossils occur in myriads of forms, in almost numberless duplications in many instances, for a newly found species may run into hundreds or thousands recovered in a single year. Names of insects newly discovered in a year contribute substantially to the catalogs. New birds, new fishes, new reptiles are added regularly to the lists although there are legions that are rare, even extremely rare, and nearly one thousand species and subspecies that will soon be extinct.

But every new meteorite brings not only its own substance to be described but may be a source of totally new information that will add new dimensions to our knowledge of earth and space.

What else is there that can give one such a sense of wonder as holding in one's hand an object that has come from space?

Perhaps some of the wonder is gone for this new generation that stands on the threshold of the sky, yet it seems to me that I have stood at the foot of the sky while man has propelled and thrust himself and his machines into its reaches, and my wonder has only increased. The sky stretches still unknown beyond where stars have led and beckons still into new fields with paths in all directions.

$5.95

# FIND A FALLING STAR

## HARVEY H. NININGER

In this remarkable book, Dr. H. H. Nininger, often called the world's foremost meteorite expert, recounts the excitement of his long love affair with "falling stars" — those "stones from the sky" that rain down upon our earth from outer space in great, but little-known profusion.

Fifty years ago the science of meteorites was at a low ebb. Nothing much had been done since 1900. It was Dr. Nininger's keen interest, however, that brought about a resurgence in an old science. His efforts, described with straightforward ease, account for more than half the "falls" recorded in the 20th century. His common sense, ingenuity, and persistence helped him develop techniques for locating a meteorite observed falling in an area 400 miles wide; he tells how he enlisted the help of farmers and ranchmen of the western plains; he recounts how, out of enthusiasm, he travelled thousands of miles to train people to find and recognize stony or iron meteorites of various sizes. At one time, Dr. Nininger's personal collection of meteorites, housed in Sedona, Arizona, where he lives, was considered one of the world's five greatest. He is the author of a number of books on the subject and has lectured widely.

This personal account of a field scientist in action should be of very special interest to amateur and professional geologists and astronomers alike, to "rock hounds," and to anyone with the slightest scientific curiosity.

Emerging from the Oklahoma cotton fields, Harvey Nininger was overwhelmed at sight of a state normal school. He was granted a conditional enrollment and soon found himself at the head of his classes in science. Seven years later he graduated from college with honors and a teaching position.

His first view of a great fire-ball plunged him headlong into an exciting new field, meteoritics, and again he was soon out in front. Thirty years later he had a world-wide reputation.

Proud of their three children and nine grandchildren, he lives in Sedona, Arizona, with his wife and co-worker, Addie, who for 58 years was always an indispensable partner.

"A great deal of practical advice... for anyone who would follow in his footsteps."—*Choice.* "A fascinating and inspiring account."—*The Science Teacher.* "An interesting and stimulating book by an acknowledged expert in this field."—*Smithsonian.* "Highly recommended."—*Sky and Telescope.*

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